SYNOPSIS OF FUNDING OPPORTUNITY
USDA-NRCS-OH-12-01

The Natural Resources Conservation Service (NRCS), an agency under the United States Department of Agriculture, is announcing availability of Conservation Innovation Grants (CIG) to stimulate the development and adoption of innovative conservation approaches and technologies. Applications are accepted for Ohio only. NRCS anticipates that the amount available for support of this program in FY 2012 will be approximately $300,000.00; $150,000 will be made available for applications covering all of Ohio and $150,000 will be made available for the applications in the Western Lake Erie Basin and Sandusky River Watersheds. Applications are requested from eligible governmental or non-governmental organizations or individuals for competitive consideration of grant awards for projects between 1 and 3 years in duration. Funds will be awarded through a nationwide competitive grants process.

This notice identifies the objectives, eligibility criteria, and application instructions for CIG projects. Applications will be screened for completeness and compliance with the provisions of this notice. Incomplete applications will be eliminated from competition, and notification of elimination will be mailed to the applicant.

The purpose of CIG is to stimulate the development and adoption of innovative conservation approaches and technologies, while leveraging the Federal investment in environmental enhancement and protection in conjunction with agricultural production. CIG projects are expected to lead to the transfer of conservation technologies, management systems, and innovative approaches into NRCS policy, technical manuals, guides, and references, or to the private sector. CIG does not fund research projects. Projects intended to test hypotheses do not qualify for a CIG grant. CIG is used to apply or demonstrate previously proven technology. It is a vehicle to stimulate development and adoption of conservation approaches or technologies that have been studied sufficiently to indicate a high likelihood of success, and that are a candidate for eventual technology transfer or institutionalization. CIG promotes sharing of skills, knowledge, technologies, and facilities among communities, governments, and other institutions to ensure that scientific and technological developments are accessible to a wider range of users. CIG funds projects targeting innovative on-the-ground conservation, including pilot projects and field demonstrations.

Applications will be screened for completeness and compliance with the provisions of this notice. Incomplete applications will be eliminated from competition, and notification of elimination will be emailed or mailed to the applicant.

NRCS will accept applications for single or multi-year projects, not to exceed 3 years, submitted to NRCS from eligible entities including federally recognized Indian tribes, State and local units of government, and non-governmental organizations and individuals. Applications are accepted for Ohio projects only.

Complete applications received by applicable deadlines will be evaluated by a technical peer review panel. Proposal applications, along with their associated technical peer review, will be forwarded to the Ohio NRCS State Conservationist for final selections.

DEPARTMENT OF AGRICULTURE
AGENCY: Natural Resources Conservation Service, Commodity Credit Corporation

ACTION: NOTICE
Conservation Innovation Grants Fiscal Year (FY) 2012 Announcement for Program Funding

Catalog of Federal Domestic Assistance (CFDA) Number: 10.912

SUMMARY: The Natural Resources Conservation Service (NRCS), an agency under the United States Department of Agriculture, is announcing availability of Conservation Innovation Grants (CIG) to stimulate the development and adoption of innovative conservation approaches and technologies. Applications are accepted for Ohio only. NRCS anticipates that the amount available for support of this program in FY 2012 will be approximately $300,000.00; $150,000 will be made available for applications covering all of Ohio and $150,000 will be made available for the applications in the Western Lake Erie Basin and Sandusky River Watersheds (see Exhibit A for map of the watersheds) . Applications are requested from eligible governmental or non-governmental organizations or individuals for competitive consideration of grant awards for projects between 1 and 3 years in duration.

Funds will be awarded through a nationwide competitive grants process.

This notice identifies the objectives, eligibility criteria, and application instructions for CIG projects. Applications will be screened for completeness and compliance with the provisions of this notice. Incomplete applications will be eliminated from competition, and notification of elimination will be mailed to the applicant.

DATES: Applications for the proposal phase must be received at 200 North High Street, Room 522, Columbus, Ohio 43215 by 4 p.m. Eastern Standard Time (EST) on April 2, 2012.

ADDRESSES: Applications sent via United States Postal Service, hand-delivery, express mail or overnight courier service must be sent to the following address: Natural Resources Conservation Service, 200 North High Street, Room 522, Columbus, Ohio 43215.

Applications sent electronically must be sent through Grants.gov or "moira.sanford@oh.usda.gov".

For more information contact:

John Armentano
CIG Program Manager
Natural Resources Conservation Service
200 North High Street, Room 522
Columbus, Ohio 43215
Phone: (614) 255-2469
E-mail: john.armentano@oh.usda.gov

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SUPPLEMENTARY INFORMATION

I. FUNDING OPPORTUNITY DESCRIPTION

A. Legislative Authority

The Conservation Innovation Grants (CIG) program was authorized as part of the Environmental Quality Incentives Program (EQIP) [16 U.S.C. 3839aa-8] under Section 2509 of the Food, Conservation, and Energy Act of 2008 (Public Law 110-246). The Secretary of Agriculture delegated the authority for the administration of EQIP and CIG to the Chief of the Natural Resources Conservation Service (NRCS), who is Vice President of the Commodity Credit Corporation (CCC). EQIP is funded and administered by NRCS under the authorities of the CCC.

B. Overview

The purpose of CIG is to stimulate the development and adoption of innovative conservation approaches and technologies, while leveraging the Federal investment in environmental enhancement and protection in conjunction with agricultural production. CIG projects are expected to lead to the transfer of conservation technologies, management systems, and innovative approaches into NRCS policy, technical manuals, guides, and references, or to the private sector. CIG does not fund research projects. Projects intended to test hypotheses do not qualify for a CIG grant. CIG is used to apply or demonstrate previously proven technology. It is a vehicle to stimulate development and adoption of conservation approaches or technologies that have been studied sufficiently to indicate a high likelihood of success, and that are a candidate for eventual technology transfer or institutionalization. CIG promotes sharing of skills, knowledge, technologies, and facilities among communities, governments, and other institutions to ensure that scientific and technological developments are accessible to a wider range of users. CIG funds projects targeting innovative on-the-ground conservation, including pilot projects and field demonstrations.

Applications will be evaluated by NRCS staff under the bulleted topics identified by the applicant (see Section 1 Letter D). Applications will be screened for completeness and compliance with the provisions of this notice. Incomplete applications will be eliminated from competition, and notification of elimination will be emailed or mailed to the applicant.

NRCS will accept applications for single or multi-year projects, not to exceed 3 years, submitted to NRCS from eligible entities including federally recognized Indian tribes, State and local units of government, and non-governmental organizations and individuals. Applications are accepted for Ohio projects only.

Complete applications received by applicable deadlines will be evaluated by a technical peer review panel based on the Criteria for Application Evaluation identified in the application instructions in Section V Letter B.

Proposal applications, along with their associated technical peer review, will be forwarded to the Ohio NRCS State Conservationist (State Conservationist). The State Conservationist will make the final selections.

C. Innovative Conservation Projects or Activities

For the purposes of CIG, the proposed innovative project or activity must encompass the development, field testing, evaluation, implementation, and monitoring of:

- Conservation adoption approaches or incentive systems; or
- Promising conservation technologies, practices, systems, procedures, or approaches; or
- Environmental soundness with goals of environmental protection and natural resource enhancement.

To be given priority consideration, the innovative project or activity should:

- Make use of a proven technology or a technology that has been studied sufficiently to indicate a high probability for success;
- Demonstrate and verify environmental (soil, water, air, plants, energy, and animal) effectiveness, utility, affordability, and usability of conservation technology in the field;
- Adapt conservation technologies, practices, systems, procedures, approaches, and incentive systems to improve performance and encourage adoption;
- Introduce conservation systems, approaches, and procedures from another geographic area or agricultural sector;
- Adapt conservation technology, management, or incentive systems to improve performance; and
- Demonstrate transferability of knowledge.

D. Grant Component

For FY 2012, NRCS Ohio will consider offering CIG in the following areas: Soil Heath, Nutrient Management, and CIG Project Assessment. The Soil Health and CIG assessment components are not offered in the Western Lake Erie Basin and Sandusky River Watersheds.

Proposals that demonstrate the use of innovative technologies and/or approaches to address at least one bulleted topic listed below will be considered. Proposals must identify the most appropriate bulleted topic the innovation/technology is addressing. While NRCS is interested in receiving proposals for each bulleted topic below, special interest is placed on receiving proposals that address topics identified as a “Priority Need.” Additional topics (not listed below) may be considered at the State Conservationist’s discretion. If an additional topic is proposed for the State Conservationist’s consideration, it must be identified as such in the proposal.

1. Soil Health (Not applicable to the Western Lake Erie Basin and Sandusky River Watersheds)

- **Priority Need:** Demonstrate and quantify the impacts of cover crops, crop rotations, tillage and/or soil amendments on soil chemical, physical, and/or biological properties and their relationships with nutrient cycling, soil water availability, and plant growth.
- **Priority Need:** Demonstrate and quantify the rate of increase in available soil water holding capacity as a function of soil properties, management practices (e.g. tillage, amendments, crop residue inputs), and/or climate.
- **Priority Need:** Disseminating the information that is collected through field days, job sheets, and other methods to help NRCS encourage adaptation of the practices.
- Demonstrate innovative seeding methods of cover crops and multiple species cover crop mixes to allow for earlier establishment and increased biomass production.
- Demonstrate the effects of grazing management of cover crop mixes on soil chemical, physical and biological properties health and water quality.

- Demonstrate and quantify differences in nutrient and available water holding capacity of a soil system resulting from long-term no-till with cover crops compared to systems using tillage or rotational tillage.

2. ***Nutrient Management (Western Lake Erie Basin and Sandusky River Watersheds applications only)***
   - **Priority Need:** Demonstrate and quantify the optimal combinations of nutrient source, application rate, placement, and application timing (4 Rs), as measured by impact on nutrient use efficiency and yield for one or more of the following: corn, soybeans, wheat, vegetables, hay/pasture, cotton, and/or rice. Demonstrations are encouraged that show how these optimal combinations change for one or more of the following comparisons: irrigated vs. non-irrigated management, tillage vs. reduced tillage systems, manure-amended vs. non manure-amended systems, and/or organic vs. conventional production systems.
   - Demonstrate new and innovative advances in precision farming technologies related to low disturbance fertilizer injection and quantify the effects on nutrient use efficiency, yield, and producer risk.
   - Demonstrate active methods which improve on the capture of phosphorus in manure management systems and provide the opportunity to recycle the manure phosphorus in lieu of synthetic fertilizers. Examples may include: technologies for animal manures; technologies that help growers deal with excess manure by means of exports or other value added products that generate income for the grower; and quantifying the impacts of innovative technologies that decrease phosphorus losses from the field (e.g., biofilters, wetland restoration, drainage water management).
   - Demonstrate and quantify the effectiveness of bundling conservation measures to avoid, control, and trap nutrient losses from the field.
   - Demonstrate and quantify the effectiveness of Enhanced Efficiency Fertilizer products; including inhibitors, delayed release products, or biological solutions; on yield and nutrient use efficiency.
   - Demonstrate and quantify the effectiveness of methods to capture dissolved phosphorus from field runoff and subsurface drainage.
   - Demonstrate technologies which can improve cost efficiency of transporting manure nutrients from regions of dense populations of animal agriculture operations to areas with low densities of animal operations that have demand for manure nutrients.

3. ***CIG Projects Assessment (Not applicable to the Western Lake Erie Basin and Sandusky River Watersheds)***
   - **Priority Need:** Conduct an assessment of completed CIG projects in Ohio on a given topic to identify and recommend those projects that should be adopted along with the associated conservation practice standards that would incorporate those findings. If the findings of the project need further clarification, recommendations should be made as to what additional information is needed. Copies of the four final reports are attached in Exhibit B of this announcement.

II. FUNDING AVAILABILITY

A. NRCS Ohio's Component

NRCS Ohio anticipates that the amount available for support of this program in FY 2012 will be approximately $300,000; $150,000 for all of Ohio and $150,000 for the Western Lake Erie Basin and Sandusky River Watersheds.

CIG will fund single and multi-year projects, not to exceed 3 years (anticipated project start date of September 1, 2012). Funds will be awarded through a nationwide competitive grants process. The maximum award amount for any project will not exceed $75,000.

III. ELIGIBILITY INFORMATION

CIG applicants must be a Federally recognized Indian tribe, State or local unit of government, non-governmental organization, or an individual.

A. Matching Funds

Selected applicants may receive CIG grants of up to 50 percent of their total project cost. CIG recipients must match the USDA funds awarded on dollar-for-dollar basis from non-Federal sources with cash and in-kind contributions. Of the applicant's required match (50%), a minimum of 25 percent of the total project cost must come from cash sources; the remaining 25 percent may come from in-kind contributions.

In-kind costs of equipment or project personnel cannot exceed 50 percent of the applicant's match (except in the case of projects carried out by either a Beginning Farmer or Rancher, Limited Resource Farmer or Rancher, or Federally recognized Indian tribe or a community-based organization comprised of or representing these entities). The remainder of the match must be provided in cash.

Matching funds must be secured at time of application. Applications should include written verification of commitments of matching support (including both cash and in-kind contributions) from third parties. Additional information about matching funds can be found at: 2 CFR 215.

B. EQIP Payment Limitation and Duplicate Payments

Section 1240G of the Food Security Act of 1985, 16 U.S.C. 3839aa-7, imposes a $300,000 limitation for all cost-share or incentive payments disbursed to individuals or entities under an EQIP contract between fiscal years 2008 and 2012. The limitation applies to CIG in the following manner:

- CIG funds are awarded through grant agreements. These grant agreements are not EQIP contracts; thus, CIG awards in and of themselves are not limited by the payment limitation.
- Direct or indirect payments made to an individual or entity using funds from a CIG award to carry out structural, vegetative, or management practices count toward each individual's or entity's EQIP payment limitation. Through project progress reports, CIG grantees are responsible for certifying that producers involved in CIG projects do not exceed the payment limitation. Further, all direct and indirect payments made to

producers using CIG funds must be reported to the NRCS CIG program manager in the semi-annual report. Direct or indirect payments cannot be made for a practice for which the producer has already received funds, or is contracted to receive funds through any USDA programs (EQIP, Agricultural Management Assistance, Conservation Security Program, Conservation Stewardship Program, Wildlife Habitat Incentive Program, etc.) because that would be a duplicate payment.

C. Project Eligibility

To be eligible for CIG, projects must involve landowners who meet the EQIP eligibility requirements as set forth in 16 USC 3839aa-1. Further, all agricultural producers receiving direct or indirect payments through participation in a CIG project must also meet the EQIP eligibility requirements. Additional information regarding EQIP eligibility requirements can be found at: http://www.nrcs.usda.gov/programs/eqip/. Participating producers are not required to have an EQIP contract.

A person or legal entity will not be eligible to receive any benefit during a crop, fiscal, or program year, as appropriate, if the average adjusted gross non-farm income of the person or legal entity exceeds $1,000,000, unless not less than 66.66 percent of the average adjusted gross income of the person or legal entity is average adjusted gross farm income (7 CFR Part 1400).

A person who is determined ineligible for USDA program benefits under the Highly Erodible Land Compliance and Wetland Compliance provisions of the Food Security Act of 1985 will not be eligible to receive direct or indirect payments through CIG.

Technologies and approaches that are eligible for funding in a project's geographic area through EQIP are ineligible for CIG funding except where the use of those technologies and approaches demonstrates clear innovation. The burden falls on the applicant to sufficiently describe the innovative features of the proposed technology or approach (applicants should reference the appropriate State's EQIP Eligible Practices List by contacting the NRCS State office).

The grantee is responsible for providing the technical assistance required to successfully implement and complete the project. NRCS will designate a Program Contact, Administrative Contact, and Technical Contact to provide oversight for each project receiving an award.

IV. APPLICATION and SUBMISSION INFORMATION

A. INFORMATION FOR PROPOSALS

All Office of Management and Budget standard forms necessary for CIG submission are posted on the following web site: Grants.gov - Forms Repository. An application checklist is available on the CIG Web site: http://www.nrcs.usda.gov/technical/cig/index.html.

1. Content and Format

Applications are required to contain the content, format, and information set forth below in order to receive consideration for funding. Applicants should not assume prior knowledge on the part of NRCS or others as to the relative merits of the project described in the application. Applicants must submit one copy of the application in the following format:

- Applications should be typewritten or printed on 8½” x 11” white paper. The text of the application should be in a font no smaller than 12-point, single-spaced, single-sided, with one-inch margins and page numbered.
- Applications that fail to comply with the required content and format will not be considered for funding.

Applications must include all required forms and narrative sections described below. Incomplete applications will not be considered.

2. **Proposal Cover Sheet:** (Standard Form 424 Application for Federal Assistance) Applicants must use this document as the cover sheet for each project application. Standard Form 424 can be downloaded from Grants.gov - Forms Repository. By signing the SF-424, you agree to the following:
   a. By submitting this grant/agreement application, the undersigned attests that the applicant has not been convicted of a felony criminal violation under Federal or State law in the 24 months preceding the date of signature, nor has any officer or agent of the applicant been convicted of a felony criminal violation under Federal or State law in the 24 months preceding the date of signature.
   b. By submitting this grant/agreement application, the undersigned attests that the applicant does not have any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.
3. **Project Description:** The description must include the following information and is limited to 12 pages in length.
   Project background: Describe the history of, and need for, the proposed innovation. Provide evidence that the proposed innovation has been studied sufficiently to indicate a good probability for success of the project.
   a. Project objectives: Be specific using qualitative and quantitative measures, if possible, to describe the project’s purpose and goals. Describe how the project is innovative.
   b. Project methods: Describe clearly the methodology of the project and the tools or processes that will be used to implement the project.
   c. Location and size of project or project area: Describe the location of the project and the relative size and scope (e.g., acres, farm types and demographics, etc.) of the project area. Provide a map, if possible.
   d. Producer participation: Estimate the number of producers involved in the project, and describe the extent of their involvement (all producers involved in the project must be eligible for EQIP).
   e. Project action plan and timeline: Provide a table listing project actions, timeframes, and associated milestones through project completion. Anticipated project start date of September 1, 2012.
   f. Project management: Give a detailed description of how the project will be organized and managed. Include a list of key project personnel, their relevant education or experience, and their anticipated contributions to the project. Explain the level of participation required in the project by government and non-government entities. Identify who will participate in monitoring and evaluating the project.

g. Project deliverables/products: Provide a list of specific deliverables and products that will allow NRCS to monitor project progress and payment.

   In addition to specific deliverable, applications must include the following activities as deliverables:
   a. Semi-annual reports
   b. Supplemental narratives to explain and support payment requests
   c. Final report
   d. Performance items specific to the project that indicate progress [A thorough list and explanation of measurable performance items specific to the project will be used in the technical evaluation (refer to "CIG Technical Evaluation Criteria")]
   e. New technology and innovative approach fact sheet
   f. Participation in at least one NRCS CIG Showcase or comparable NRCS event during the period of the grant

4. **Benefits or results expected and transferability:** Identify the results and benefits to be derived from the proposed project activities, and explain how the results will be measured. Identify project beneficiaries, i.e., agricultural producers by type, region, or sector; rural communities; and municipalities. Explain how these entities will benefit. In addition, describe how results will be communicated to others via outreach activities.
5. **Project evaluation:** Describe the methodology or procedures to be followed to evaluate the project, determine technical feasibility, and quantify the results of the project for the final report. Grant recipients will be required to provide a semi-annual progress report, quarterly financial reports, and a final project report to NRCS. Instructions for submitting quarterly reports will be detailed in the grant agreement.
6. **Additional Information:** Bibliographies and/or resumes (not to exceed two pages per person), and references.
7. **Assessment of Environmental and Social Impacts:** Describe and assess the anticipated environmental effects of the proposed project. The description of the potential environmental and social impacts must address all potential beneficial and adverse impacts of the proposed action. A full description and assessment of the potential impacts to all environmental resources must be disclosed. One line or short descriptions of environmental impacts are not acceptable. The length of the analysis should be commensurate with the complexity of the project proposed and the environmental resources impacted either directly, indirectly (later in time), or cumulatively. Where possible, information on environmental impacts should be quantified, such as number of acres of wetlands impacted, amount of carbon sequestration estimated, etc. Environmental resources include soil, water, air, plants, and animals, as well as other specific resources protected by law, Executive Order, and agency policy. These resources are outlined in the NRCS Environmental Evaluation Worksheet, form NRCS-CPA-52, which is available at: NRCS-CPA-52. The NRCS-CPA-52 form can be used as a guide for the scope of environmental information that should be prepared for this section of the application. In addition to describing impacts, applicants are required to assess the significance or degree of potential environmental impact of the proposed project on environmental resources. Applicants may consult with the NRCS Environmental Liaison concerning the scope of what should be addressed in this section of the application. The Environmental Liaison for Ohio is Mark DeBrock at 614-255-2462 or mark.debrock@oh.usda.gov

Note: Please be aware that applications for projects with potentially adverse impacts may need to be modified in order to achieve acceptable and beneficial levels of environmental impact. If projects cannot be modified, there is potential that during the screening process the application may not be selected.

8. **Budget Information:** The budget portion of the application consists of three parts described below.
   a. Standard Form (SF) 424A Budget Information- Non-Construction Programs: Fill in all spaces as appropriate. Section B, Item 6, column 1 should reflect the NRCS funds and Column 2 should reflect the cost share funds. If your cost share is from multiple sources you may show that in the remaining columns of Item 6. This form is the summary budget for the project.
   b. Detailed Budget Description: Specific item by item breakdown of the totals provided in Item 6 of the SF-424A should be provided. This detail should show what individual costs were added together to arrive at the totals presented in each of Object Class Categories on the SF-424. The format of this information should be readable in 8.5 by 11 printable pages. It may be in a chart, spreadsheet, table, etc. The information needs to be presented in such a way that the evaluators and NRCS can readily understand what expenses will be incurred to support the project. The breakdown of the federal share and the cost share should be shown separately as in the SF-424A, not combined. This may be on separate documents or on different sections of the same presentation. Listed below are some suggested items that should be shown in the budget details. These are suggested details and are not inclusive:
      6a. Personnel; A list of personnel, their salary, hourly rate, hours, % time
      6b. Fringe Benefits: % of salary, differing rates for different staff
      6c. Travel: basis for airfare, mileage rate (NTE Federal govt. rate), per diem, hotel, car rental, how many trips, how many days, number of staff
      6d. Equipment: type of equipment, cost per item, per batch, per load, quantity
      6e. Supplies: type of supplies, cost per item, per batch, per load, quantity (a general statement such as "office supplies $3,000" is not acceptable)
      6f. Contractual; Cost of each subcontract – the total of all subcontracts should be shown on the SF-424, but an itemized budget should be provided for each potential subcontract. The budgets for the subcontracts should follow this same format and be submitted with your proposal.
      6g. Construction: N/A
      6h. Other: Cost per item, per batch, per load, quantity
   c. Budget Narrative: Provide a detailed narrative in support of the budget for the project, broken down by each project year. Discuss how the budget specifically supports the proposed activities. Explain how budget items are essential to achieving project objectives. Justify the project cost effectiveness and include justification for personnel and consultant salaries with a description of duties. In addition to the information above, the subcontractors and consultants must also submit a statement of work. The budget narrative should support the federal funds requested and the cost share.
9. **Indirect Costs**
   If you have a current Federally Negotiated Indirect Cost Agreement you must:

a. Submit a copy of the agreement with your application,
b. Calculate indirect costs based on the total Federal Funds awarded and cannot exceed 15 percent,
c. Requesting unrecovered indirect costs in the matching funds is not approved.

If you do **not** have a current Federally Negotiated Indirect Cost Agreement you may not claim indirect costs in this application.

10. **Matching:** Applications must include written verification of commitments of matching support (including both cash and in-kind contributions) from non-federal third parties.

    <u>Cash Match</u>
    For any third party cash contributions, a separate pledge agreement is required for each donation, signed by the authorized organizational representative of the donor organization and the applicant organization, which must include: (1) the name, address, and telephone number of the donor, (2) the name of the applicant organization, (3) the title of the project for which the donation is made, (4) the dollar amount of the cash donation, and (5) a statement that the donor will pay the cash contribution during the grant period.

    <u>In-Kind Match</u>
    "In-kind" refers to non-cash contributions of goods or services made by third party individuals or organizations to support projects. Examples of “in-kind” include work done by unpaid volunteers and donations of supplies, facilities, or equipment. In-kind contributions must be necessary to accomplish program activities and are verifiable.

    For any third party in-kind contributions, a separate pledge agreement is required for each contribution, signed by the authorized organizational representatives of the donor organization and the applicant organization, which must include: (1) the name, address, and telephone number of the donor, (2) the name of the applicant’s organization, (3) the title of the project for which the donation is made, (4) a good faith estimate of the current fair market value of the third party in-kind contribution, and (5) a statement that the donor will make the contribution during the grant period.

    The sources and amounts of all matching support from outside the applicant institution must be summarized on a separate page and placed in the application immediately following the summary of matching support (matching support means a budget narrative broken down by year).

    The value of applicant contributions to the project will be established in accordance with the applicable cost principles. Applicants should refer to OMB Circulars, Cost Principles that apply to their entity for additional guidance, and other requirements relating to matching and allowable costs.
11. **Declaration of Previous CIG Projects Involvement:** Identify any previously awarded CIG projects involvement related to this proposal and any of its principal investigators. Detail the purpose, outcomes to date, and how this new proposal relates to the previous award.
12. **Declaration of Beginning Farmer or Rancher, Limited Resource Farmer or Rancher, or Federally Recognized Indian Tribe:** If an applicant wishes to

compete in one of these categories, the applicant must make a declaration in writing of their status as a Beginning Farmer or Rancher, Limited Resource Farmer or Rancher, or Federally recognized Indian tribe or a community-based organization comprised of or representing these entities. This declaration is also required in order to be eligible for the in-kind contribution exception.

13. **Certifications:** Standard Form (SF) 424B - Assurances, Non-construction Programs. All applications must include this document. The SF-424B may be found at: Grants.gov - Forms Repository or by contacting the State office. Applicants, by signing and submitting an application, assure and certify that they are in compliance with the following from 7 CFR:
    a. Part 3017, Government wide Debarment and Suspension (Non-procurement)
    b. Part 3018, New Restrictions on Lobbying
    c. Part 3021, Government wide Requirements for Drug Free Workplace (Financial Assistance)
14. **DUNS Number:** A Dun and Bradstreet (D&B) Data Universal Numbering System (DUNS) number is a unique nine-digit sequence recognized as the universal standard for identifying and keeping track of over 70 million businesses worldwide. CIG applicants must obtain a DUNS Number. Information on how to obtain a DUNS number can be found at: http://fedgov.dnb.com/webform or by calling 1-866-705-5711. Please note that the registration may take up to 14 business days to complete.
15. **Central Contractor Registry (CCR) Registration:** The CCR is a database that serves as the primary government repository for contractor information required for the conduct of business with the government. This database is also used as a central location for maintaining organizational information for organizations seeking and receiving grants from the government. CIG applicants must register with the CCR. To register, go to: http://www.ccr.gov. Allow a minimum of 5 days to complete the CCR registration.
16. **How to Submit an Application**

    Applicants may submit applications electronically through Grants.gov or to the e-mail address listed below. Alternatively, applications may be submitted in person or via express mail, overnight courier service, or U.S. Postal Service to the addresses listed below. Applications submitted through Grants.gov or e-mail must contain all of the elements of a complete package and meet the requirements described above. Instructions for electronically submitting the required standard forms, and instructions for adding attachments are posted on Grants.gov. Applications submitted electronically are date and time stamped by Grants.gov and must be received by the identified closing date of April 2, 2012. E-mailed applications must be received by NRCS before the submission deadline.

    Note: NRCS is not responsible for any technical malfunctions or web site problems related to Grants.gov or e-mailed submissions. Applicants should begin the Grants.gov process or send their e-mail in advance of the submission deadline to avoid problems.

    E-mail address: moira.sanford@oh.usda.gov

    The address for submitting an application via United States Postal Service, hand-delivery, express mail or overnight courier service is:

Moira Sanford, Contract Specialist
Natural Resources Conservation Service
200 North High Street, Room 522
Columbus, Ohio 43215
Phone (614) 255-2495

Note: Applicants must submit one signed copy of each project application.

Applications submitted by fax will not be considered.

17. Due Date

Applications must be received at 200 North High Street, Room 522, Columbus, Ohio 43215 by 4:00 p.m. EST on April 2, 2012. The applicant assumes the risk of any delays in application delivery. Applicants are strongly encouraged to submit completed applications via Grants.gov, e-mail, overnight mail, or delivery service to ensure timely receipt by NRCS.

18. Acknowledgement of Submission

NRCS will acknowledge receipt of timely applications via e-mail. An applicant who does not receive such an e-mail acknowledgement within 30 days of their submission but believes he/she submitted a timely application must contact the NRCS program contact below within 30 days. Failure to do so will result in the application not being considered for the second phase of the application process.

CIG Program Contact:
John Armentano
CIG Program Manager
200 North High Street, Room 522
Columbus, Ohio 43215
Phone: (614) 255-2469
E-mail: john.armentano@oh.usda.gov

19. Withdrawal

Applications may be withdrawn by written notice at any time before selections are made. Applications may be withdrawn by the applicant, or by an authorized representative.

20. Funding Restrictions

Awardees may not use unrecovered indirect costs as part of their matching funds.

CIG funds may not be used to pay any of the following costs unless otherwise permitted by law, or approved in writing by the Authorized Departmental Officer in advance of incurring such costs:

a. Costs above the amount of funds authorized for the project;
b. Costs incurred prior to the effective date of the grant;
c. Costs which lie outside the scope of the approved project and any amendments thereto;
d. Entertainment costs, regardless of their apparent relationship to project objectives;

e. Compensation for injuries to persons, or damage to property arising out of project activities;
f. Consulting services performed by a federal employee during official duty hours when such consulting services result in the payment of additional compensation to the employee; and,
g. Renovation or refurbishment of research or related spaces; the purchase or installation of fixed equipment in such spaces; and the planning, repair, rehabilitation, acquisition, or construction of buildings or facilities.

This list is not exhaustive. Questions regarding the allowances of particular items of cost should be directed to the administrative contact person.

21. Review

Applications will be screened for completeness and compliance with the provisions of this notice. Incomplete applications will be eliminated from competition, and notification of elimination will be emailed or mailed to the applicant. Complete applications will be evaluated by a technical peer review panel based on the Criteria for Application Evaluation identified in the application instructions in section V.B.

Applications with technically-based recommendations from the peer review groups will be forwarded to the Grants Review Board. The Grants Review Board will make recommendations for project approval to the State Conservationist who will make the final selections.

22. Patents and Inventions

Allocation of rights to patents and inventions shall be in accordance with USDA regulation 7 CFR §3019.36 and 7 CFR §3019.2. USDA receives a royalty-free license for Federal Government use, reserves the right to require the patentee to license others in certain circumstances, and requires that anyone exclusively licensed to sell the invention in the United States must normally manufacture it domestically.

23. Environmental Review Requirements

The Council on Environmental Quality's National Environmental Policy Act (NEPA) regulations at 40 CFR parts 1500-1508 and the NRCS regulation that implements NEPA at 7 CFR part 650 require that an environmental review be prepared for actions where the agency has discretion and control. Accordingly, NRCS financial assistance under the CIG program requires compliance with these regulations. As part of the application packet, applicants are required to provide environmental information pertaining to their project to help NRCS determine the appropriate documentation required to comply with NEPA and NRCS regulations. If the application is selected for funding, the NRCS Program Contact and NRCS Environmental Liaison will coordinate with the selected applicant concerning documentation for compliance with NEPA. The selected applicant will be required to prepare and pay for the preparation of the appropriate NEPA document (e.g., Environmental Assessment or Environmental Impact Statement if required for NEPA compliance). Grant funding cannot be approved until the environmental review requirements demonstrating compliance with NEPA are met.

V. APPLICATION REVIEW INFORMATION

A. Review and Selection Process

There are three steps in evaluating CIG proposals. Proposals will be divided among a Technical Peer Review Panel. The Technical Peer Review Panel consists of NRCS technical specialists, and technical specialists from other appropriately related groups and individuals. Applications will be reviewed based on the CIG Technical Evaluation Criteria listed in Part VI.B below.

The Technical Peer Review Panel will forward their recommendations and the proposals to the State Conservationist for final review and selection.

B. Criteria for Application Evaluation

Peer review panels will use the following criteria to evaluate project proposals:

Purpose, Approach, and Goals

- Design and implementation of project based on sound methodology and demonstrated technology.
- Promotes environmental enhancement and protection in conjunction with agricultural production.
- Project outcome is clearly measurable.
- Potential for successful completion.
- Both beneficial and adverse impacts are considered and an acceptably significant level of improvement will be achieved.

Innovative Technology or Approach

- Project is innovative (national, regionally, and local in nature).
- Project conforms to description of innovative projects or activities in proposal request announcement.

Project Management

- Timeline and milestones are clear and reasonable.
- Project staff has technical expertise needed.
- Budget is adequately explained and justified.
- Experience and capacity to partner with and gain the support of other organizations, institutions and agencies.

Transferability

- Potential for producers and landowners to use the innovative technologies or approaches.
- Potential to transfer the approach or technology nationally or to a broader audience or other geographic or socio-economic areas, including limited resource, socially disadvantaged and other traditionally underserved producers and communities.
- Potential for NRCS to successfully use the innovative approach or methods.
- Project will result in the development of technical or related technology transfer materials (technical standards, technical notes, guide sheets, handbooks, software, etc.).

C. Anticipated Announcement and Award Dates

CIG selections are anticipated to be announced by August 1, 2012; all agreements are expected to be awarded by September 1, 2012. Funds are not awarded, and work may not start until an agreement is signed by both NRCS and the grantee.

Applicants should plan their projects based on a project start date of September 1, 2012.

VI. AWARD ADMINISTRATION INFORMATION

A. Award Notification

Applicants who have been selected for funding will receive a letter of official notification. However, all selections are contingent upon successful completion of the environmental review process and financial review. NRCS reserves the right to have grant award(s) administered by a third party. In the event that a third party administers the grant award(s), the applicant/recipient will be notified in writing.

B. Environmental Review Requirements

Upon notification of selection, the applicant must contact the NRCS Environmental Liaison to determine the scope and level of NEPA documentation required for the project. The environmental documentation prepared to meet NEPA requirements must be prepared prior to award of grant funds.

Selected applicants may be required to prepare and pay for the preparation of the appropriate NEPA document(s) if an Environmental Assessment or Environmental Impact Statement is needed. Grant funds cannot be awarded until the environmental review requirements demonstrating compliance with NEPA are met. The NRCS Environmental Liaison for Ohio is Mark DeBrock, 614-255-2462 or mark.debrock@oh.usda.gov.

VII. AGENCY CONTACTS

CIG Program Contact:

John Armentano
CIG Program Manager
200 North High Street, Room 522
Columbus, Ohio 43215
Phone: (614) 255-2469
E-mail: john.armentano@oh.usda.gov

CIG Administrative Contact:

Moira Sanford
Contract Specialist
200 North High Street, Room 522
Columbus, Ohio 43215
Phone: (614) 255-2495
E-mail: moira.sanford@oh.usda.gov

Additional information about CIG, including fact sheets and frequently asked questions, is available on the CIG web page at: http://www.nrcs.usda.gov/technical/cig/index.html.

Signed this ___________ day of ____________________ in Columbus, OH.

TERRY J. COSBY
State Conservationist
Natural Resources Conservation Service

Attachments

CONSERVATION INNOVATION GRANTS
FISCAL YEAR 2012 APPLICATION PACKAGE CHECK LIST

☐ **A. Proposal Cover Sheet:** Submit Standard Form 424 Application for Federal Assistance

☐ **B. Project Description:** (12 pages maximum, single-spaced, single-sided, 12 point font)

1. Project background
2. Project objectives
3. Project methods
4. Location and size of project area (include a map if possible)
5. Producer participation
6. Project action plan and timeline
7. Project management
8. Project deliverables/products
9. Benefits or results expected and transferability
10. Project evaluation

☐ **C. Additional Information:** Bibliography, resumes, and/or references

☐ **D. Assessment of Environmental and Social Impacts**

☐ **E. Budget Information:** Submit a completed Standard Form 424A (SF-424A) Budget Information-Non-Construction Programs.

1. Complete SF-424A
2. Detailed budget description
3. Budget narrative

☐ **F. Indirect Cost**

☐ **G. Matching Information**

☐ **H. Declaration of Previous CIG Projects Involvement.**

☐ **I. Declaration of Beginning Farmer or Rancher, Limited Farmer or Rancher, or Federally Recognized Indian tribe (Special Provisions):** If applicable, include a statement declaring your status as a Beginning Farmer or Rancher, Limited Resource Farmer or Rancher, or federally recognized Indian tribe, or community-based organization representing these entities.

☐ **K. Certifications:** Complete Standard Form 424B (SF-424B) Assurances-Non-Construction Programs.

☐ **L. DUNS Number:** For information about how to obtain a DUNS number, go to http://fedgov.dnb.com/webform or call 1-866-705-5711. Please note that the registration may take up to 14 business days to complete.

☐ **M. Central Contractor Registry (CCR):** To register, visit www.ccr.gov. Allow a minimum of 5 days to complete the CCR registration.

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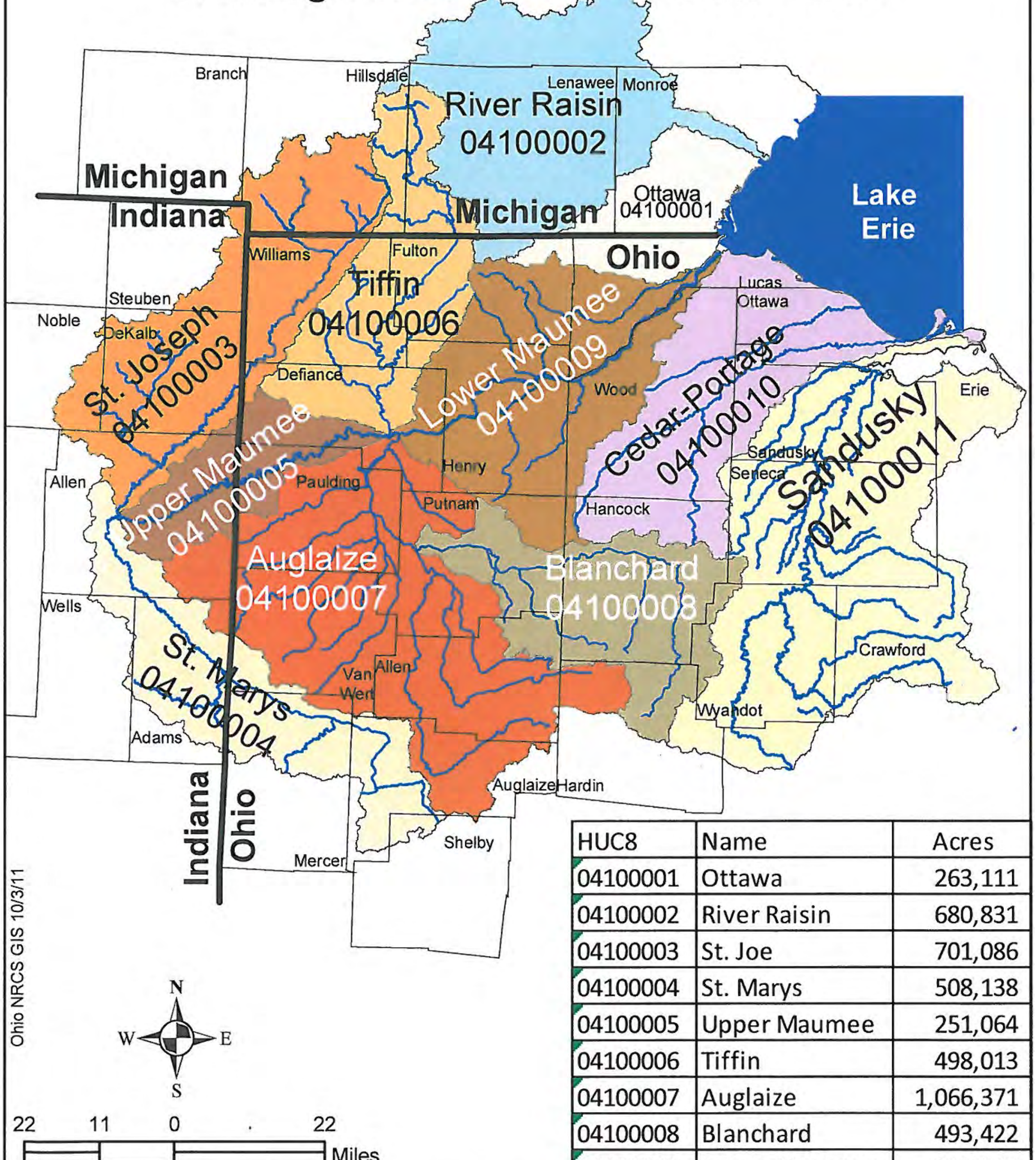
To file a complaint of discrimination, write to USDA, Assistant Secretary for Civil Rights, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue, S.W., Stop 9410, Washington, DC 20250-9410, or call toll-free at (866) 632-9992 (English) or (800) 877-8339 (TDD) or (866) 377-8642 (English Federal-relay) or (800) 845-6136 (Spanish Federal-relay). USDA is an equal opportunity provider and employer.

EXHIBIT A

U. S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE

Drainage Near Western Lake Erie



Terry J. Cosby, USDA-NRCS State Conservationist, 614-255-2472

An Equal Opportunity Employer and Provider

HUC8	Name	Acres
04100001	Ottawa	263,111
04100002	River Raisin	680,831
04100003	St. Joe	701,086
04100004	St. Marys	508,138
04100005	Upper Maumee	251,064
04100006	Tiffin	498,013
04100007	Auglaize	1,066,371
04100008	Blanchard	493,422
04100009	Lower Maumee	692,415
04100010	Cedar-Portage	613,617
04100011	Sandusky	1,167,777
	Total =	6,935,845

EXHIBIT B

Project 1

Final Report

NRCS Conservation Innovation Grants – Final Report

Agreement Number: **69-5E34-07-86**
Grantee Name: **Environmental Defense Fund**
Project Title: **Advancing Farmer-Friendly, highly Effective Nutrient Use Efficiency Tools: Evaluation, Demonstration and Farmer Education**
Project Director: **Karen Chapman**
Contact Information: **Environmental Defense Fund, 223 North Union Street, Delaware, Ohio 43015, (740) 363-8269, kchapman@edf.org**
Period Covered by Report: **April through July, 2010**
Project End Date: **September 30, 2010**

Phase:	Third Year Spring/Summer Phase: Lay out and geo-reference N rate plots for all existing CIG participants, conduct soil samples, side-dress N.
Describe progress prior to this report	Grower participants were identified, replicated N test plots established according to Dr. Mullen and OSU Extension protocol, plots were soil tested (PSNT) and side-dressed. Corn stalk N tests were completed – 10 samples in four locations in each field, a total of 3,840 stalks, during the first two years of the project. As part of an extended On-Farm Network activity, aerial photography with infrared imaging capability and yield data are being collected for each field each year, including for the CIG N plots, which aids greatly in interpreting data. First year data was compiled and analyzed and presented to producers at January 09 winter meetings. Two groups of producers representing 96 fields in 7 counties participating in the CIG and On Farm Network gathered in Bryan, Ohio to hear presentations from Joe Nester of Nester Ag, Tracy Blackmer of the Iowa Soybean Association's On Farm Network, Robert Mullen of OSU Extension, and John McGuire of Simplified Technology Services. For the second year (2009), all CIG plots planned for 2009 were laid out and georeferenced, side-dressed N, and soil sampled. There were a total of 22 cooperators participating this year. A wet spring set corn planting back and collection and analysis of CSNT will be later this year. In 2009 CCAs instructed cooperators to apply four rates of N instead of five: 100 lbs, 150 lbs, 200 lbs, 250 lbs total N replicated, then one strip of 50 lbs N non-replicated, as most farmers had yield losses at 50 lbs during the first year and preferred not to replicate. Most farmers are also signed up for American Farmland Trust BMP Challenge for the reduced rate (50 lbs) strip. The CCA consultants involved in this project also work individually with producers to apply Phosphorus according to soil

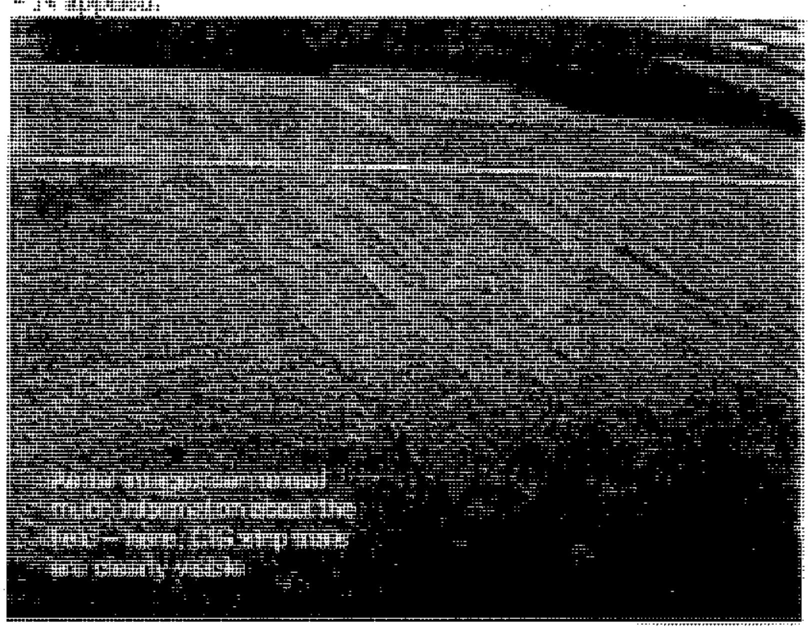
	test data, at nominal rates banded 2" beneath soil surface, and avoids winter applications of fertilizer on frozen or snow-covered ground. Aerial imagery was completed for all participating fields for 2009. CSNT was delayed due to a later-then-normal harvest but was completed in October for all participating fields. Yield data was collected in November and December. CCA consultants reviewed and analyzed the aerial imagery, yield maps, CSNT results and other field data and prepared sheets for each participant, as well as slides showing the data in aggregate. Winter meetings were held February 3 – 4, 2010, near Fort Wayne Indiana and in Bryan, Ohio (see attached photo). The meeting in Ohio included all producers participating in the CIG strip trials and the Maumee On-Farm Network. The meeting in Indiana included producers potentially interested in participating in both strip trials and farmer-driven data collection as part of an expanding Maumee On-Farm Network. This adds tremendous value to the nitrogen strip trials and PSNT/CSNT, when farmers can review information related to nitrogen inputs with additional tools such as aerial imagery and remote sensing combined with yield data and guided stalk sampling in additional fields. Participation in CIG strip trials will continue with producers in Ohio and may potentially include Indiana producers, so we are greatly expanding the reach of the project without an additional expenditure of funds. Some producers lost money in the plots with lower N rates (<200#), particularly during 2009, due to an extended cool, wet spring with higher-than-normal (+5") rainfall in June. However, in general, the N test plots are showing that lower-than-normal application rates can achieve economically optimum yields. So, economic optimum yields in 2009 required higher N rates than the previous season (10# to 20#/acre) but still below what most growers have typically applied.
Describe progress this quarter	Participating plots for 22 producers in Ohio and 24 producers in Indiana are confirmed and laid out for 2010. Again this year CCAs managing the project will use four rates of N with one plot per producer in the 50#/acre rate. Plots have been geo-referenced, soil sampled and side-dressed. This Spring was particularly challenging; many producers missed an early, short planting window in April and were unable to get back into fields to plant until late May due to several weeks of steady moisture in NW Ohio that prohibited clay soils from drying sufficiently. Some of the corn that was

	planted early also showed signs of stress and some CIG plots had to be re-plotted in order to obtain better results.
Describe progress planned next quarter	All CIG plots and On Farm Network participating fields will be flown for aerial photography using infrared spectrum technology, and guided cornstalk tests conducted just prior to harvest.

Summary of findings: what did we learn?

This year is the final year of the Conservation Innovation Grant-funded strip trials. Data will be collected through the fall and compared with the previous two years' data to provide farmers with three years of solid data that can provide guidance on optimum rates of N for most efficient plant uptake, economic savings to the farmer, and fewer nutrients lost. The data will again be presented in winter meetings in 2011, even though the NRCS-funded portion of the grant will have expired and funds expended.

Consultants involved in the project gained valuable insight from conducting the strip trials in combination with On-Farm Network adaptive management techniques such as aerial imagery and guided CSNT. The way the CIG and On Farm Network worked in combination was as follows: N plots were laid out according to protocol and geo-referenced, providing a guide for the aerial imagery to be taken, then soil tested and side-dressed as detailed in the above summary. Aerial imagery was taken for all CIG plots as well as On Farm Network fields (see photo below). The CSNT samples were "guided" for the CIG plots based on the aerial imagery and taken from both lower N-applied strips and higher N-applied strips. These samples were added to the aggregate data and compared with the On Farm Network field guided stalk samples to provide more information on the break-even point – or the point where optimum N uptake was achieved and utilized by the crop for greatest return in yield, without excess – or "luxury" – N applied.



During winter meetings (see photo below), data is presented to farmers and their guests in aggregate and analysis provided on the findings. While it is difficult to draw specific conclusions on two years' worth of data, cooperators were able to see how their farm "stacked up" in comparison with other farms and how efficient their fertilizer inputs were in actually getting to the plant.

At winter meetings, producers review aerial images and CSNT as well as information on Nitrogen use efficiency

The findings consistently point to efficient N use being a function of how much the plant can take up, which in turn is a function of a variety of factors including soil health, residual N, moisture, elevation, etc, all of which can vary markedly across a seemingly homogenous field. As a result the consultants involved in the project, as well as the farmers they work with, have concluded that applying N on the basis of per-bushel yield or as a blanket field-wide formula will not achieve the efficiency in either N use or economic bottom line for the farmer as would varying N rates based on yield "zones" that take into account field variability, combined with continuous annual analysis from soil testing, PSNT, aerial imagery and guided stalk samples.

Moreover, the cooperating farmers have found that the past methods of determining N rates tend to be too broad and lead to over-application in many instances, since they are yield goal based. They have also realized, through participating in the strip trials and the On Farm Network, that many variables within their farming system affect the efficiency of Nitrogen, including soil structure and type, tillage practices, timing of nutrient application, as well as nutrient source. They are very interested in continuing their trials to find a much more accurate N rate for their own operation.

In conclusion, the CIG plots have continued to show that higher rates are not necessary and producers can reach economic optimum yield at lower rates, even in wetter years. A comparison of the data from 2008 with 2009 showed that there were nitrogen losses in 2009 due to the wet winter, wet spring and late onset of spring. Given that, the economic optimum N rate in 2009 was higher than the previous season (around 15 to 20 lbs. of nitrogen/acre higher) but still below what most growers have typically applied.

By going through this exercise and participating in the strip trials, the producers involved have gained extremely valuable proof that higher N rates do not necessarily lead to higher profits or higher yield, and many now feel confident that lowering their N rates based on solid information produced from their own fields can be a wise choice. The data show that lowering N rates even by a relatively small amount (c. 20# per acre) can lower per acre expenditures on fertilizer without harming yield. Since these cooperators represent some 50,000 acres planted in corn and wheat across the watershed, a 20# average reduction in N applications could hypothetically mean a reduction of one million pounds of N not applied and not lost to the environment. As leaders and innovators in the agricultural community in their part of the Western Lake Erie Basin, these producers in turn can influence other producers in the region, leading to much broader impact.

Armentano, John - Columbus, OH

~om: Karen Chapman [kchapman@edf.org]
nt: Tuesday, January 11, 2011 5:03 PM
,o: Armentano, John - Columbus, OH
Subject: P data

John, please let me know if the attached is sufficient for reporting purposes. I'm sorry I didn't ask them to keep this information ready to go, it was really an oversight on my part, not theirs. But, the results were definitely worth it due to the reduced P rates.

Karen

Evaluation of P use efficiency using soil tests within strip trials and as appropriate based upon soil P levels, evaluation of no P applications within 2 strip trials on 30 farms, 3 year enrollment.

30 fields of average of 40-acre plots (1,200 acres) with Nitrogen plots also had variable rate P applied by geo-referenced management zones within the plots. These zones were developed either from soil survey or from yield map interpretation. Any starter was kept constant, but for the most part the starter fertilizers used were Nitrogen only, no P.

Variation of the Phosphorus applied ranged from 140# of MAP to as low as 60# of MAP, depending on the levels found in the zone soil tests. (MAP is 11-52-0, or 52% Phosphate). Producers saw no yield reduction where Phosphorus rates were reduced. Producers with these plots were able to run VRT by management zone rather than the normal flat rate, which reduced P inputs where needed on those 1,200 acres, resulting in roughly 600 acres of lower rates. Rates were reduced on an average of 80# MAP, or 41.6# P2O5, or about 18.5# of actual P. So, 600 acres x 18.5 = 11,100# actual P applied. Under normal circumstances a total rate closer to 140# would have been applied in order to fertilize for the most limiting factor, resulting in a savings of about 73,000 # of P. The VRT fertilizer definitely saved fertilizer from being over-applied, and conducting soil tests in the plots provided information with which to vary-rate P successfully.

Project 2

Drainage Water Management - Demonstration and Evaluation for Ohio Agriculture Conservation Innovation Grant
Final Report, Progress and Future Plans

Maumee Valley RC&D

The Ohio State University, Food, Agricultural and Biological Engineering

USDA, Agricultural Research Service, Soil Drainage Research Unit

ODNR Division of Soil and Water Resources

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Department of Food, Agricultural, and Biological Engineering
The Ohio State University
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Dr. Norman R. Fausey Research Leader
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fausey.1@osu.edu; 614-292-9806

Submitted March 10, 2011

INTRODUCTION

Original Project Abstract

CIG Component: Technology Component; Drainage Water Management
Title: Drainage Water Management – Demonstration and Evaluation for Ohio Agriculture
Duration: October 1, 2006 – September 30, 2009
Director: Brian Miller, P.E., Secretary, Maumee Valley RC&D, 06879 Evansport Road, Ste. E Defiance, OH 43512

Collaborators:
Ohio Department of Natural Resources, DSWC (Mark Seger)
OSU/FABE/Overholt Drainage Education and Research Program (Larry C. Brown)
Ohio State University Extension Defiance Co.(Bruce Clevenger)
Maumee Valley RC&D (Scott Miller)
USDA, ARS, Soil Drainage Research Unit (Norman Fausey)
USDA, Farm Service Agency (Todd Brace)
USDA, NRCS (Steve Davis)
Agricultural Drainage Management Coalition (Tade Sullivan)
The Nature Conservancy (Gary Moore)
Ohio Corn Growers Association (Mike Wagner)
Ohio Farm Bureau Federation (Larry Antosch)
Ohio Land Improvement Contactors Association
Ohio Federation Soil and Water Conservation Districts
OSU Extension in counties w/farmer collaborators
Demonstration site landowners and operators
Environmental Defense Fund (Terry Noto)

Graduate Students and Undergraduate Students:
Yuhui Shang (MS), Ehsan Ghane (PhD), Stephan Gunn (PhD), Vinayak Shedekar (PhD), Mark Wahl (MS), Justin McBride (Ug), other undergraduates in limited use.

Estimated number of EQIP-eligible producers involved in the project: 16
Natural resource concern(s)/technology to be addressed: Drainage water management

List of deliverables/products of project activities:
(1) Field evaluations of environmental effectiveness of drainage water management
(2) Field evaluations of crop yields and profitability of drainage water management
(3) Synthesis of environmental effectiveness and crop productivity on a regional basis, and educational materials for drainage water management use in Ohio and the Midwest
(4) Recommendations and guidelines for DWM system management during the growing season and non-growing season for SWCDs, NRCS, Extension, Ag consultants, and farmers.

Summary of the work to be performed:
Artificial subsurface drainage systems have been in use in the Midwest for nearly 150 years. These systems facilitate crop production in areas that would be otherwise unsuitable, and increase yield in others. Almost invariably, they were designed for the sole purpose of quickly and safely removing excess water from the plant root zone to prevent wet stress, to improve trafficability and crop yields, but with no consideration of their effects on water quality. In this

project we seek to promote and characterize the innovative practice of drainage water management (DWM) at larger scales than has previously taken place and in four watersheds in western Ohio. DWM is a water quality BMP for managing drainage outlet elevation to reduce nutrient transport from agricultural subsurface drains during the fallow season, and the practice may be able to help reduce crop deficit water stress during the growing season. Local cooperators will implement DWM systems on paired fields on their farms. We will measure flow and collect water quality samples. These samples will be analyzed for nitrogen compounds. Farmer cooperators will provide DWM system management information, cropping system information, crop yields, etc., and provide input on how best to manage these systems to achieve water quality and profitability benefits. Project information will be disseminated in scientific articles, a dedicated website, educational and technical publications, and farm forums and field days held around Ohio. Project data and results will facilitate the adoption of technology for the development of drainage water management in the region. We will develop expertise to document nutrient savings from DWM, a necessary step in nutrient trading.

Notes: This report covers the period 2007 through December 2010, and provides a summary of our progress, results, and data. We are committed to continue this effort through the next five years to be able to gain a better understanding of how drainage water management can be implemented successfully in Ohio.

Background from original proposal:
Subsurface or "tile" drainage is a common practice in agricultural regions with seasonal high water tables. The practice of subsurface drainage provides many agronomic and environmental benefits, including greater water infiltration, lower runoff and soil loss, improved trafficability, and improved crop growth and yield compared with similar agricultural soils without subsurface drainage. However, subsurface drains have been found to increase losses of nitrate-N, which is of increasing concern because of the significant contribution to nitrate in the receiving streams from drained agricultural land in Ohio. Drainage Water Management (DWM) is a practice that shows great promise for reducing nitrate loading, while maintaining drainage benefits during critical periods of the crop growth cycle. DWM uses water control structures to raise the effective height of the drain outlet, and thereby manages the amount of drainage from a field. DWM has been used for nutrient management in North Carolina for years, and recent data from Ohio research sites show the potential for large reductions in nitrate loads in Ohio. Past research has shown the effectiveness of DWM at the plot scale, but now we implementation on a larger, field-scale level to validate the benefits to Ohio farmers. There are very limited data from Ohio sites on the economic potential of this practice, which provides the potential to hold soil water that can be used later in the season. Data from private farms in Ohio conditions are needed to draw conclusions. Other farmer questions focus on the impacts on soil structure and soil biological activity, especially earthworms, due to the higher winter water table. To address all of these needs, we will demonstrate and evaluate the water quality, soil quality, yield impacts and profitability of the DWM practice on private farms in four watersheds: Western Lake Erie Basin, Upper and Middle Scioto River Basin, Miami River Basin, and the Grand Lake St. Marys Basin.

Note: A map showing all ten sites is located in a later section.

Project Objectives:
This CIG project will accomplish the following objectives:

(1) To demonstrate and evaluate the environmental effectiveness of DWM technologies in Ohio, under a variety of soils and climate conditions;

(2) To evaluate and demonstrate the usability of DWM and its impact on crop yields and farm profitability in Ohio; and
(3) To transfer the information gained to agencies and producers for use in making decisions, through summarizing data, producing educational and technical materials for the practice, and hosting field days and other educational events to demonstrate the practices for farmers.
The proposed Ohio CIG project and its activities are compatible with, and supplemental to the regional proposal submitted to the CIG by the Agricultural Drainage Water Management (ADWM) Coalition (Urbandale, IA), titled ***Drainage Water Management for Midwestern Row Crop Agriculture***.

Note: Portions of the regional report are attached.

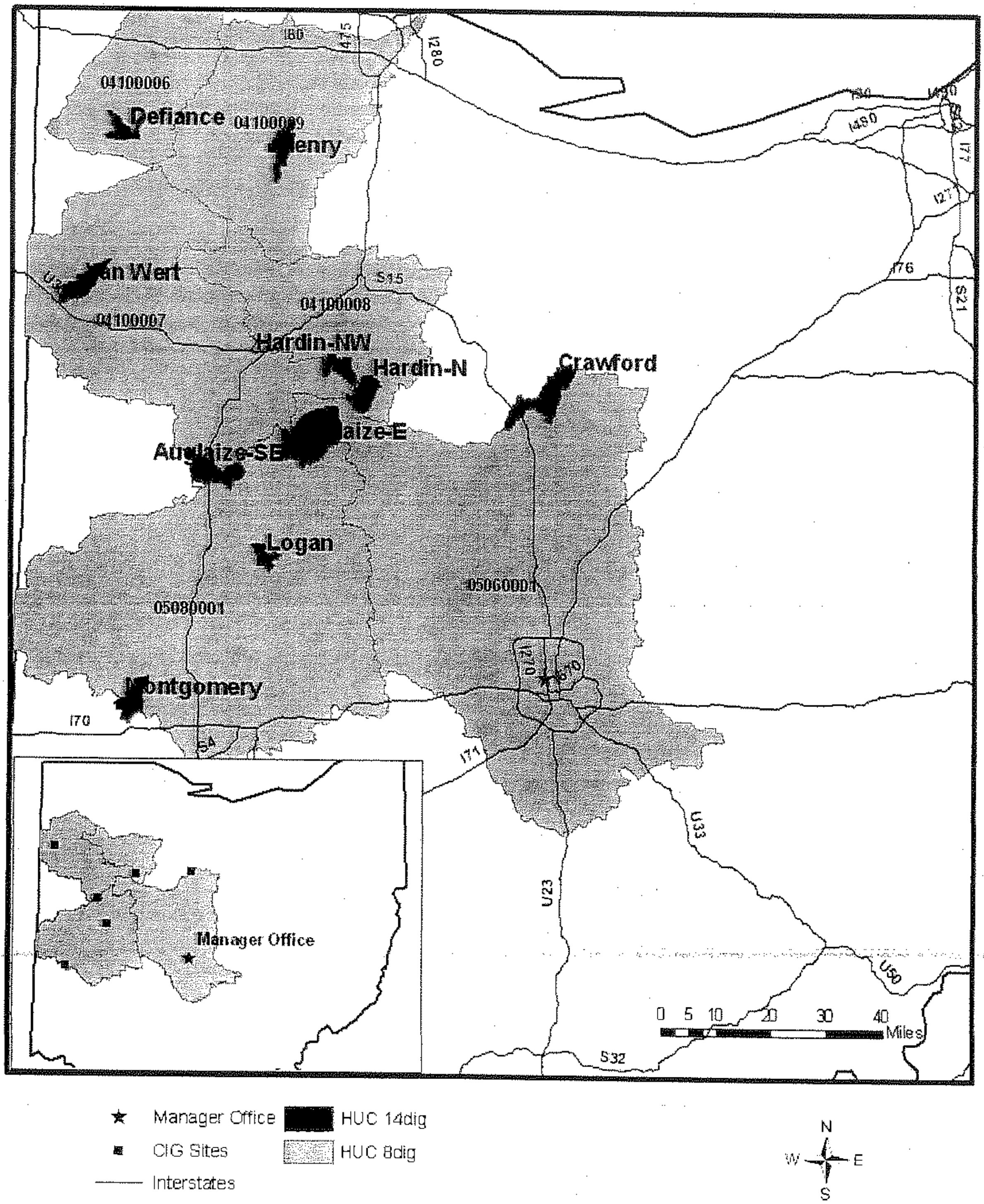
Project Methods with notes on progress:
The project's main focus areas include engaging producers to help the team evaluate the multiple benefits of DWM on farm economics, soil quality, and water quality; assessing the magnitude of nutrient reduction benefits achievable with DWM systems, and improving the water and nutrient accounting for these systems; assessing earthworm activity and soil organic matter changes; and effectively disseminate this information to the farming community, and agencies and the industry serving agriculture in Ohio and the Midwest. The following section provides the general methodologies to address the project's main focus areas, and project objectives.

Notes: In a few cases the methodology may have been changed or enhanced. The number of sites up and running at this time are 10, with data from 2008-2009, and some from 2010, being collected.

Field Evaluations (Objectives 1 and 2):
In each of the four watersheds, we will monitor new and/or existing field sites to evaluate the environmental effectiveness of DWM. It will be necessary to retrofit well-documented existing subsurface drainage systems with drainage water management structures and associated mains. All sites will be selected (see criteria below) so that DWM can be compared to conventional subsurface drainage on fields or parts of fields with similar soils, drainage systems (layout, lateral spacings/depths), cropping and management histories, and yields. Both fields at each site will be planted with the same corn hybrid or soybean variety, with the same pesticides and fertilizer rates, and tillage systems. This will allow us to use the paired watershed design to determine the impacts of DWM with a statistically well-supported method. Monitoring is needed for nitrate concentration and water flow from the subsurface drains in fields with DWM versus those with conventional subsurface drainage. In addition, a portion of each site will be monitored for water table depths, to evaluate water losses via other pathways, and to improve water and nutrient accounting. A portion of the sites will be monitored for soil quality and earthworms. The farmer collaborators will provide all necessary cropping and management information and data, so crop yields and profitability can be assessed. This is critical for producer acceptance of DWM in Ohio.

Note: We continue to recruit farmers and evaluate sites for future expansion of project efforts as additional funding becomes available. We are maintaining a list of sites to be evaluated in 2011. This work is ongoing. All sites including the regional project sites are presented below.

Ohio CIG State Sites



Flow, water quality, and water table
Water flow rates and/or volumes from subsurface drains will be monitored, and water samples for nitrate-N analysis will be taken approximately weekly at all sites (more frequently during high flow periods). Water flow and nitrate concentration measurements will be used to calculate the reduction in nitrate loads resulting from DWM practices. Some sites will be instrumented to measure water table level on a continuous basis, while others will be measured manually on a weekly basis. These measurements will improve the nutrient accounting for DWM, by determining whether there are significant losses of water and nitrate via deep or lateral seepage as a result of the practice. In addition, if lateral water seepage is detected, this might be a potential environmental benefit, as this lateral flow may contribute to stream base flow.

Notes: All sites have been instrumented to continuously measure flows in each water table control structure. A minimum number of water quality samples have been taken and analyzed. Also, we have added phosphate measurements. A final product of the water quality component will be load reduction estimates. Water table graphs for each operational site are presented in a later section of this report. This work is ongoing.

Soil quality
Sites will be monitored for potential changes in soil quality as a result of DWM, by measuring selected soil properties and earthworm populations at the beginning and end of the project.

Notes: Dr. Barry Allred has taken on this component. EC data have been collected on most sites, and EC maps have been developed on most of these sites. This work is ongoing. Dr. Allred and Bruce Clevenger converted the long-term drainage treatment plots at the DARA site (established in 1989 by the DARA board and Jim Hoorman) into a replicated DWMgt experiment.

Farm field profitability and time requirements - The economic benefits of DWM will be estimated by monitoring crop yields and production costs at each site. Yield monitors and GPS systems will measure each year's grain harvest. Where farmer collaborators do not have yield monitors and GPS, carefully managed weigh-wagon measurements will be used. Field scouts will monitor changes in weed or disease incidence. Changes in production costs will be tracked and recorded. Participating growers will be asked to record time devoted to drainage management, along with the date, and other work related activities that same day. Information on other activities will help to estimate an opportunity cost of the time devoted to drainage management. Each selected farmer collaborator will be required to sign a Memorandum of Understanding to help guarantee that necessary farming system records are properly taken and provided to the team for assessment. We also expect the farmer collaborators to provide valuable, real world input on how to best manage the DWM system for profitability and water quality.

Notes: We continue to collect crop yield data at all currently operating sites. These data are field measurements with a yield monitor on the combine. Crop yield data from the 2010 crop year are being collected now, and will be analyzed during April and May of 2011. Crop yield data collection will begin for the Montgomery and Logan sites in 2011. We have included a crop yield summary in this report, and a simple economic analyses summary.

Data Summary and Technology Transfer (Objective 3):
A database of the different sites, with soil, crop, drainage system, slope, climate, and other relevant factors will be developed. Results from the different sites will be analyzed to explain similarities and differences in effectiveness for water quality and profitability. One focus will be to provide data to NRCS that will assist them in determining program priorities and payment dollars for DWM, as well as recommendations for further developments needed. Project outcomes will be shared all across the North Central region. OSU Extension (in cooperation with team member agencies) will hold a series of "Farm Forums" at individual producers' farms distributed throughout the project target area, as well as other watersheds in the state. Local farmers and agencies will be invited to the collaborating farm(s) to discuss DWM strategies in an informal setting. We will invite experts from the participating land grant university, state and federal agencies, the drainage industry, etc., to participate in these neighbor-to-neighbor discussions of DWM strategies. OSU Extension will further develop a comprehensive teaching publication that will be used in conjunction with NCRS/University efforts on technical guidelines, as well as the variety of seminars that will be conducted as part of this project. However, the publication will be "evergreen" enough to be used as a stand-alone product to help a producer make DWM decisions, evaluate his or her water management efforts, and formulate a solid plan of drainage improvement and management on their farm. The Overholt Drainage Education and Research Program at Ohio State will produce and maintain a website where project information and data can be gathered in a central location, and disseminated to various customer groups. The material will further support the efforts of implementing DWM practices, and documenting their water quality and economic impacts. DWM system design and technical assistance educational programs for all stakeholders will be taught through various avenues, including the annual Overholt Drainage School.

<u>Notes</u>: The database has been developed and data are being entered. The Overholt Program website development has been completed, but is not online yet. This will occur sometime during 2011. Three DWMgt workshop targeted to NRCS, ODNR, and SWCD technicians and engineers was conducted in 2010, one as Session 3 of the Overholt Drainage School, and two others in August (this training was funded through a $5000 NRCS contribution agreement. Sessions on DWMgt have been conducted at the Overholt Drainage School in every year from 2006 through 2010, and will be again in 2011. A operation and management fact sheet is under development to be issued in 2011. Three Farm Fourms were conducted; one was at the Schuum site in Van Wert County in 2010.

Our outreach activities are summarized below:
Sponsored a Drainmod NII workshop (17 people - 6 hours);.
During 2007-2010, we conducted over 50 - 30 min to 1.5 hour presentations reaching well over 3500 people.
We conducted a drainage water management session at the Overholt Drainage School in 2007 (eight hours x 50+ people), 2008 (ten hours x 50+ people), 2009 (eight hours x 50+ people), and in 2010 (6 hours x 85+ people).
We (Norman, Larry and students) presented at least 5 presentations at state, national and international professional meetings reaching over 350 people in the US and China.
Publications:

Shang, Y., Brown, L.C., Fausey, N.R. and Yioussef, M.A., 2009. Evaluation of DRAINMOD-N2 for Ohio Conditions. ASABE Paper No. 090011. Presented at 2009 International Meeting of ASABE. ASAE St. Joseph, MI. 7 pp.

Cooke, R.A., G.R. Sands and L.C. Brown. 2008. Drainage Water Management: A practice for reducing nitrate loads from subsurface drainage systems. Chapter 2, Pgs 19-27 In: Final Report: Gulf Hypoxia and Local Water Quality Concerns Workshop. ASABE Publication 913C0308. 212 pp.

Frankenberger, J., E. Kladivko, G. Sands, D. Jaynes, N. Fausey, M. Helmers, R. Cooke, J. Strock, K. Nelson and L. Brown. 2007. Questions and Answers about Drainage Water Management for the Midwest. Purdue University Bulletin WQ-44. 8 Pgs.

Location and Size of Project, and Project Area:
The project spans four watersheds: Western Lake Erie Basin, Upper and Middle Scioto River Basin, Miami River Basin, and the Grand Lake St. Marys Basin. The project includes 3 or 4 field sites in each watershed. Individual fields vary in size, but the managed drainage portion of the drained fields ranges from about 10 to 30 acres. Many potential paired sites have been identified, and preliminary assessments of the soils, topography, existing drainage system, farmers collaboration potential, etc., have be made. Additional potential sites are being identified on almost a daily basis. The potential farmer collaborators already identified are committed to participating in the project, and have agreed to share yield, cropping and management information, and other data in order to determine the impacts of DWM. The fact that a number of suitable sites are already identified will lead to a very high probability of success in the proposed project.

Notes: The number of sites up and running at this time are 10, with data from 2008-2009, and some from 2010, being collected. We are expanding the number of project sites as new funding becomes available. A site description table and location map of the six sites are included in a later section called Site Descriptions.

Site Selection Criteria:
Project team members have developed draft site selection criteria, and these are being used to evaluate potential sites as they are identified. Site selection criteria include: **a)** well-documented systematic subsurface drainage system on a single field, with potential to be split into two management zones (paired fields) of near-equal size, or two separate fields of near-equal size, with very similar well-documented systematic subsurface drainage systems on each field (each field will serve as management zone), and with no adjacent property contributing flow to the existing, retrofitted, and/or new system; **b)** each potential management zone (paired field) at a site will have near-identical lateral drain spacings, similar lateral depths, etc., and a main size limited to <= 10"; c) each potential management zone must be easily available to be retrofitted with a water control structure, and associated mains/submains, with minimum cost in relation to their project impact potential; **d)** soils and topography must be the same on each management zone at each potential site, with the average land slope in any management zone being less than 2%; the size of individual fields or management zones at a site should be in the range of 10 to 30 acres; and consideration will be given in selecting sites that have near-equal effective management zones (i.e., both zones have same acreage and average land slope and soils, etc.); for example, consideration should be given to an 80-ac field with a well-documented systematic subsurface drainage system, with 0.5% average slope and same soils, that can be split into two 40-ac management zones as the potential impact at this site might be very effective and demonstrative for project goals; **e)** the potential farmer must have very good collaboration potential, and have a proven record of working well with local agencies, and if selected will sign a MOU agreeing to provide all necessary and appropriate farming systems information to the project; as well as providing input to the project on DWM system management aspects that enhance the potential for positive impacts on water quality and economics; **f)** any additional information or site attributes that enhance the project's ability to meet objectives and

goals. A number of potential sites have had initial assessments conducted by team members, and additional potential sites are being identified on almost a daily basis. The potential farmer collaborators already identified are committed to participating in the project, and have agreed to share yield, cropping and management information, and other information to the project.

Producer Participation:
Farmers from sites will participate throughout the duration of the project by providing hands-on, real-world involvement in the management of equipment, and where appropriate, gather data and report information to the project team personnel. Cooperating farmers will receive minimal compensation for providing their data and information. Additional producers will be targeted for participation in Farm Forums emphasizing the application of DWM systems.

Project Action Plan and Timeline:
Please note project timeline matrix in last section. Site selection will be completed by 3/31/2007, if not sooner. Installation of control structures and monitoring equipment is expected to be completed by 04/30/2007, but some work may not be completed until 8/31/07. Flow measurements and water quality sampling will begin at each site as soon as the infrastructure is in place. Information and data collection will be conducted throughout the project, and data and results synthesis will be similarly conducted. Semi-annual, annual, and final reports will be prepared as noted in the timeline matrix.

Note: The original matrix is not included.

Project Management:
The Maumee Valley RC&D in cooperation with the ODNR, Division of Soil and Water Conservation, will lead project management in close collaboration with the individuals listed in the abstract. Site assessment and selection will be conducted by most of the team membership. Data and information collection will be conducted by the local members of the project team (SWCD, Extension, etc.), in cooperation with the participating farmer, and in cooperation and support from the Maumee RC&D/ODNR, Ohio State University and the USDA-ARS Soil Drainage Research Unit. Data reduction and analysis will be performed by Ohio State University, in cooperation with the Soil Drainage Research Unit, and other members of the project team.

Note: Drs. Fausey and Brown will continue to provide day-to-day project management for all ten sites.

Benefits or Results Expected and Transferability:
The Ohio CIG project's field-scale producer-managed demonstration sites in the Ohio River and Lake Erie drainage basins will be vital to quantify the impact of DWM on subsurface systems flow volume reduction, water quality, and crop yields in a variety of soils and climatic conditions. The four watersheds in the project represent a large portion of the subsurface drained area of Ohio where the DWM practice has potential for implementation and results. The design and nature of this project provides clear benefits in providing regional and national guidance and recommendations for DWM system implementation, operation and management, cost-share guidance, etc. Knowledge gained from this project will encourage widespread, rapid adoption of this win/win practice. Producers will maintain profitable production levels and minimize risk. Consumers will benefit by maintaining access to a high quality, low cost, consistent source of food. Communities will benefit through access to clean water for drinking, recreation, commercial and industrial applications, and sportsmen and outdoor enthusiasts will enjoy more

abundant clean, safe water and larger populations of fish and game in managed watersheds and all watersheds downstream.

Note: This work is ongoing.

Project Evaluation:
We will evaluate effectiveness through the use of the "paired watershed" approach, in which similar fields or portions of fields will be subject to the same weather and the same management practices except for drainage management. After a period of time during which the two fields will be managed the same way, the drainage outlet will be raised on one of the fields. Any differences in the relationship between the fields during the two periods will therefore show the effectiveness of the practice in a statistically valid way. We will evaluate the project by monitoring and reporting the following in our semiannual reports: (1) the number of sites being monitored; (2) the number of cooperators that have provided the input and yield data needed for the yield and economic assessments; (3) the number of new DWM installations that result from this project; (4) the number of field days and other farmer meetings that have been held; the number of participants at these meetings; and producer, researcher, and industry feedback resulting from these activities; and (5) the number of guidance documents or educational publications produced, and feedback we receive. The project participants will schedule quarterly conference calls to communicate about the project and its progress, and to ensure the practices are being evaluated consistently among the sites. An annual report will be prepared for the project that will document the performance of each of the systems being evaluated as part of the project. The results from each watershed will be documented in a final project report synthesizing information from all the sites to evaluate the overall effectiveness of DWM in Ohio. Producer, researcher, and industry feedback resulting from all project activities will also be provided in the final report, documenting producer interest and acceptance of DWM practices.

Note: This work is ongoing.

The following sections contain data and information summaries for most of the six project sites. This includes site descriptions; site location and watershed map; individual site illustrations with the drainage plan, soils, topography, etc.; individual water table management plan and actual water table data, and precipitation; individual site cropping and management information; individual site monthly precipitation and departures from normal precipitation; and crop yield summary for 2008-2009, which includes data from the four regional sites.

We will continue this work for several more years, and expand the project if additional funding is identified. Also, we initiated a bioreactor project (abstract attached).

Summary

Does Drainage Water Management Increase Yields?

While the main benefit of Drainage Water Management is improved water quality, this practice may also benefit crop production. After two years of growing corn and soybean crops at our demonstration farms, it appears that the crop yield benefit is variable and may be related to the type of crop being grown - corn or soybean, as well as a few other factors.

Remember, we have installed water table control structures (WTCS) on fields with subsurface drainage. At each demonstration farm we have two zones; one for subsurface drainage only, and one for managed subsurface drainage. Thus we have a side-by-side comparison between conventional subsurface drainage and Drainage Water Management. Both zones at a farm have similar soils, topography, cropping and nutrient management, etc.

Our suggested WTCS management plan is as follows: After harvest, artificially raise the outlet elevation in the WTCS to 1 foot below the ground surface at the outlet. Maintain this outlet elevation throughout the winter until sometime between mid-March and mid-April. Then, adjust the WTCS so that the managed outlet elevation is several inches above the top of the outlet pipe. This elevation can be maintained until the crop stand is established, then raise the outlet elevation to 2 feet below ground surface. Usually this is done between May 15 and June 15. This plan can continue until harvest, and then it is repeated. Some of our cooperating farmers modify the suggested plan based on their experiences and their comfort with risk. It is important that the farmer checks the water level in the WTCS after rainfall events larger than 0.5 inch. We have found that as the season progresses, mid- to late-season rainfalls of 1 inch seem to cause little or no problem, especially when the soil is dry. Several of our cooperators have even left the outlet elevation at 2 feet below ground surface throughout the crop season.

So, if the farmer exercises the option to conserve some drainage water for crop use during the growing season, will Drainage Water Management help increase yields? Our data show there is some potential for increased yields, but there is much variability. For instance, for corn grown in 2008 on two farms and in 2009 on three farms, the overall average yield increase (over five farms) because of Drainage Water Management was about 11 bu/ac (actual yields were -1.0, 4.0, 13.3, 19.8 and 20.0 bu/ac). The average zone size over these five farms was 22.3 ac (actualy zone sizes were 15.6, 17.7, 19.2, 20.6, and 38.3 ac). For soybean in 2008 and 2009, the overall average yield increase (over seven farms) because of Drainage Water Management was about -8.2 bu/ac (actual yields were -10.2, -1.5, -1.2, 0.8, 1.0, 2.2, and 2.9 bu/ac). The average zone size over these seven farms was 21.6 ac (actualy zone sizes were 10.0, 15.6, 17.7, 19.0, 19.2, 19.8, and 49.8 ac). Between these farms, there are differences in soils, topography, zone sizes, corn and soybean varieties, planting dates, cropping and nutrient management, etc. However, based on these preliminary results, on the average corn yields generally increase, and soybean yields generally decrease with Drainage Water Management.

What about the economics? Again, economics will vary. I estimate for the sake of this article, that when retro-fitting an existing system, the average cost of materials and installation of an 8" WTCS on approximately 20 ac is between $3,100 and $4,340. The materials will include the WTC structure (approx $900), anti-seep collar ($135), up to 40' of 8" PVC pipe or other non-perforated solid pipe ($145), animal guard ($10), and several 8" fittings/couplings ($50) for a total of $1,240. Installation might range between 1.5 and 2.5 times the cost of the WTC structure, $1,860 to $3,100. Then the total cost/ac is from $155 to $217. With the potential to increase corn yields by about 11 bu/ac, and if we consider corn at $3.00/bu, the extra income per acre is $33. Thus, we cover the cost of the materials, supplies and installation in 4 to 6 years. If the EQIP eligible landowner receives 50% cost share, then the payoff is 2 to 3 years. Considering $6.00/bu corn, if sustained, the payoff is again 2 to 3 years. Lastly, if the landowner receives 50% cost share and $6.00/bu for corn, the payoff is between 1 and 2 years.

The above is a simple analysis and does not consider all possible costs, but it helps illustrate the potential payback of Drainage Water Management for corn. Of course it appears to be a different story for soybean, at least at this time. After a few more years of crop yield data, we can provide yield improvement information with more confidence.

Drainage Water Management has great potential to help improve water quality, and possibly increase crop yields. We are collecting information from real-world farms to illustrate potential yield benefits. We believe that as our farmers gain experience, we should see an improvement in both corn and soybean yields. But the jury is still out.

Selected data and information for six sites that are part of the MVRCD project follow. Portions of the regional report (ADMC) are attached.

Site Descriptions

Table 1- Ohio site descriptions for the MVRCD project.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Site name	Auglaize-SE	Crawford	Hardin-N	Van Wert	Montgomery	Logan
Managed drainage (acres)	17.7	49.5	19.2	10.0	–	–
Conventional drainage (acres)	18	19.5	15.8	9.4	–	–
Soil types*	Mp, BoA	TrA, TrB, Co, Lu, Pm	BoA,Pm, GwB	HtA	CsA, CeB, Bs	CeB, CrA, Mt, SIA, Wu
Watershed name	Auglaize	Upper Scioto	Blanchard	Auglaize	Upper Great Miami	Upper Great Miami
10 or 30 years yearly precipitation averages (in)	36.82	34.27	37.86	37.86	42.25	–
Installation date of system month/ year	–	August 07	–	–	–	Dec 02
Depth of tile (ft)	2.5-4	2.5-4	2.5-4	2.5-4	2.5-4	2.5-4
Tile spacing (ft)	40	–	50	40	66	30
New or retrofit system	retrofit	new	retrofit	retrofit	retrofit	new
Installation date of control structure	Sep 07	August 07	April 07	August 07	2008	March 08
Laterals on the contour (Yes or No)?	no	no	no	no	no	no

***- Mp=Montgomery silty clay; Bo=Blount silt loam; Tr=Tiro silt loam; Co=Colwood silt loam; Lu=Luray silty clay loam; Pm= Pewamo silty clay loam; Gw= Glynwood silt loam; Ht=Hoytville silty clay; Cs=Crosby silt loam; CeB=Celina silt loam; Bs=Brookston silty clay loam; Cr=Crosby silt loam; Mt= Montgomery silty clay loam; Sl=Sleeth silt loam; Wu=Westland silty clay loam.**

Note: We have information or are making arrangements to get the missing information in this table.

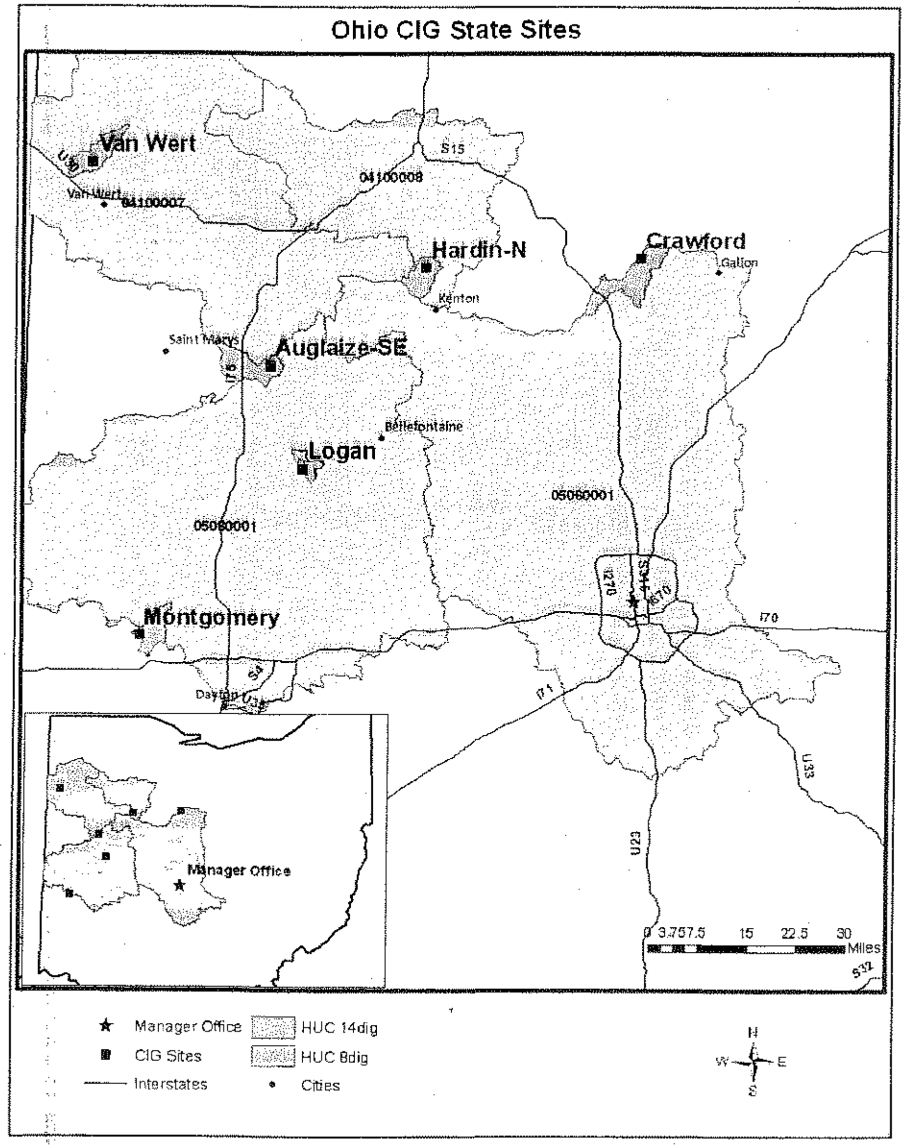


Figure 1- Location of CIG state sites in Ohio.

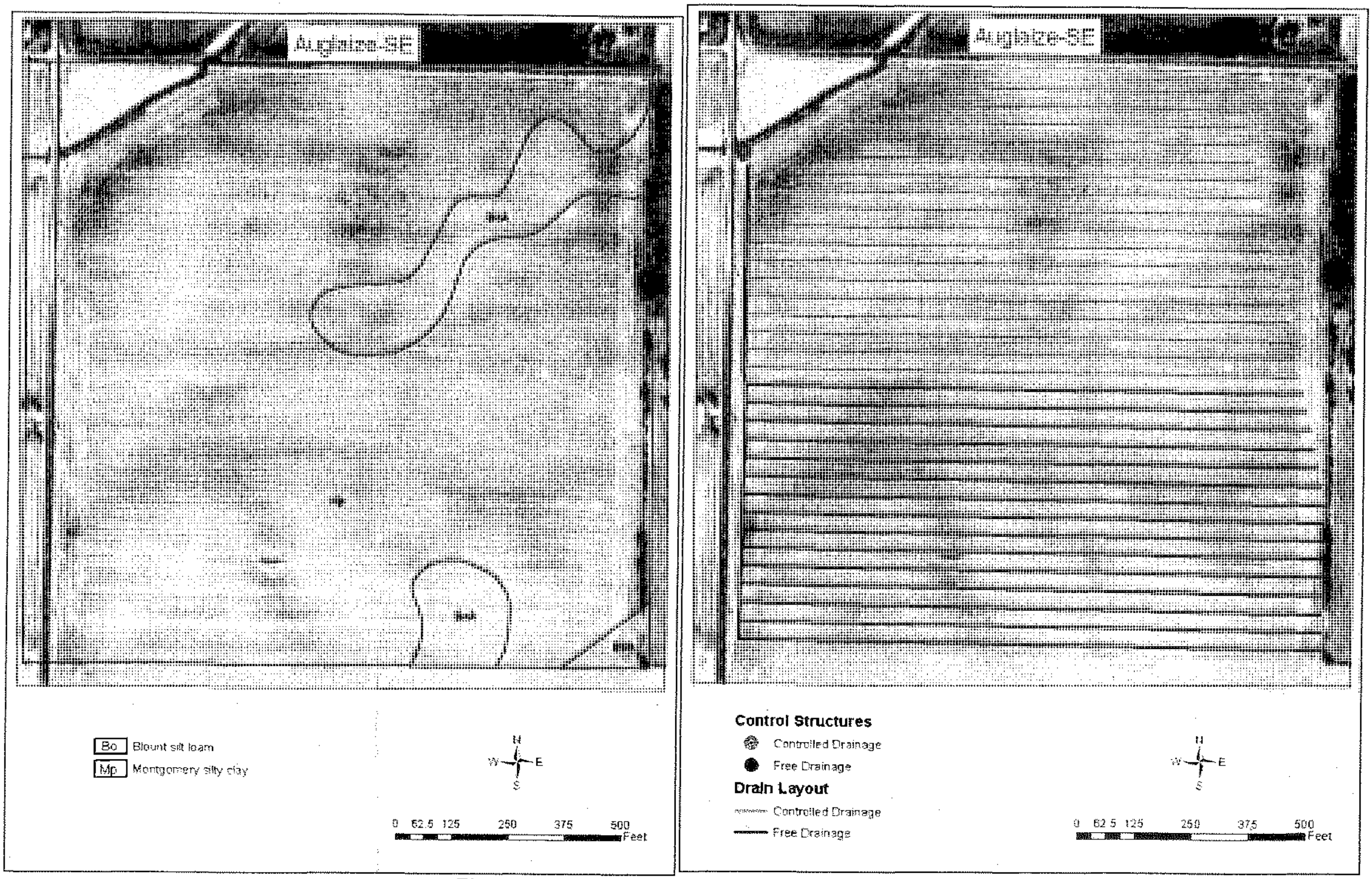


Figure 2- Auglaize-SE site soil and tile map.

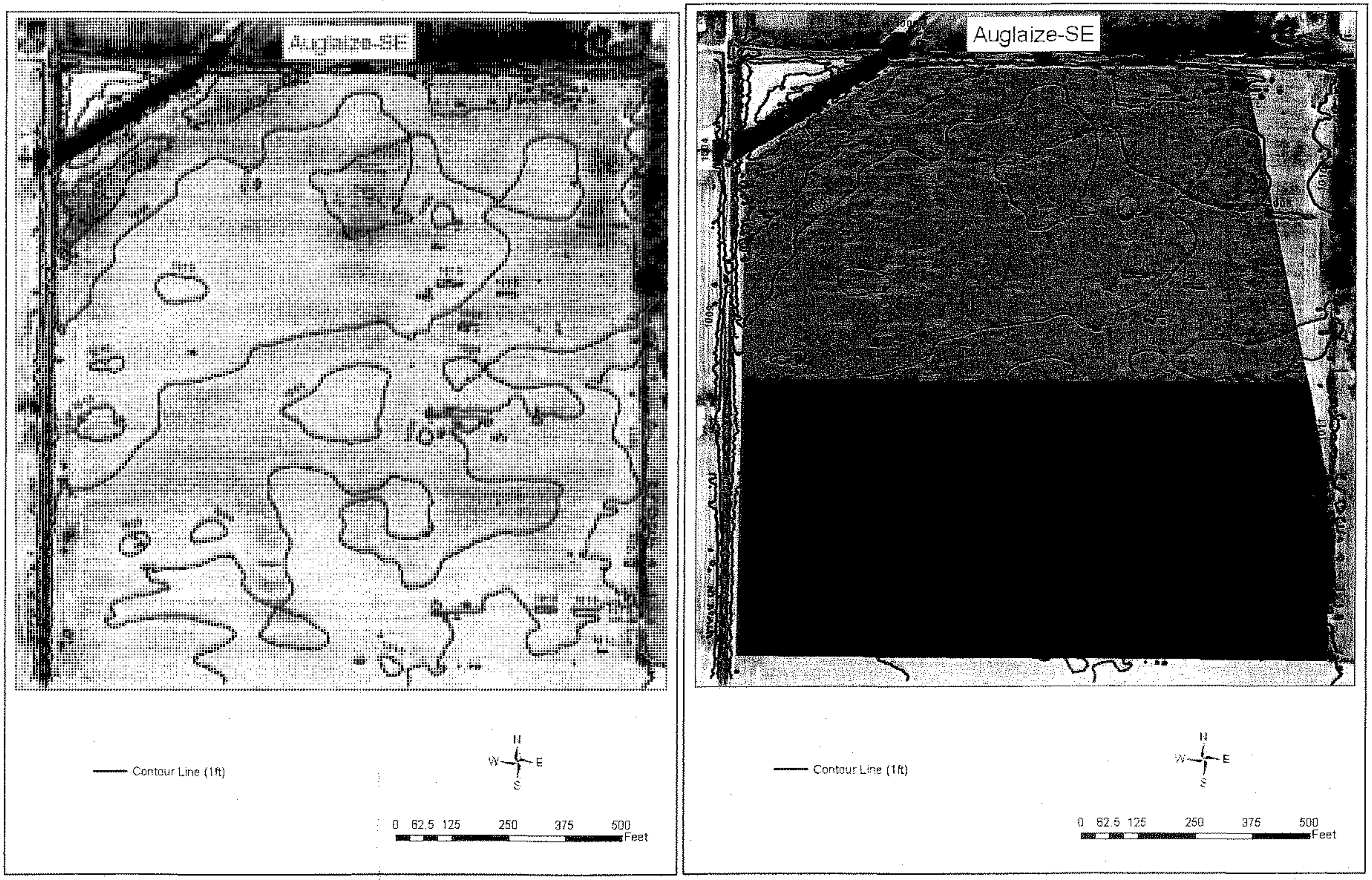


Figure 3- Auglaize-SE site topographical and aerial map.

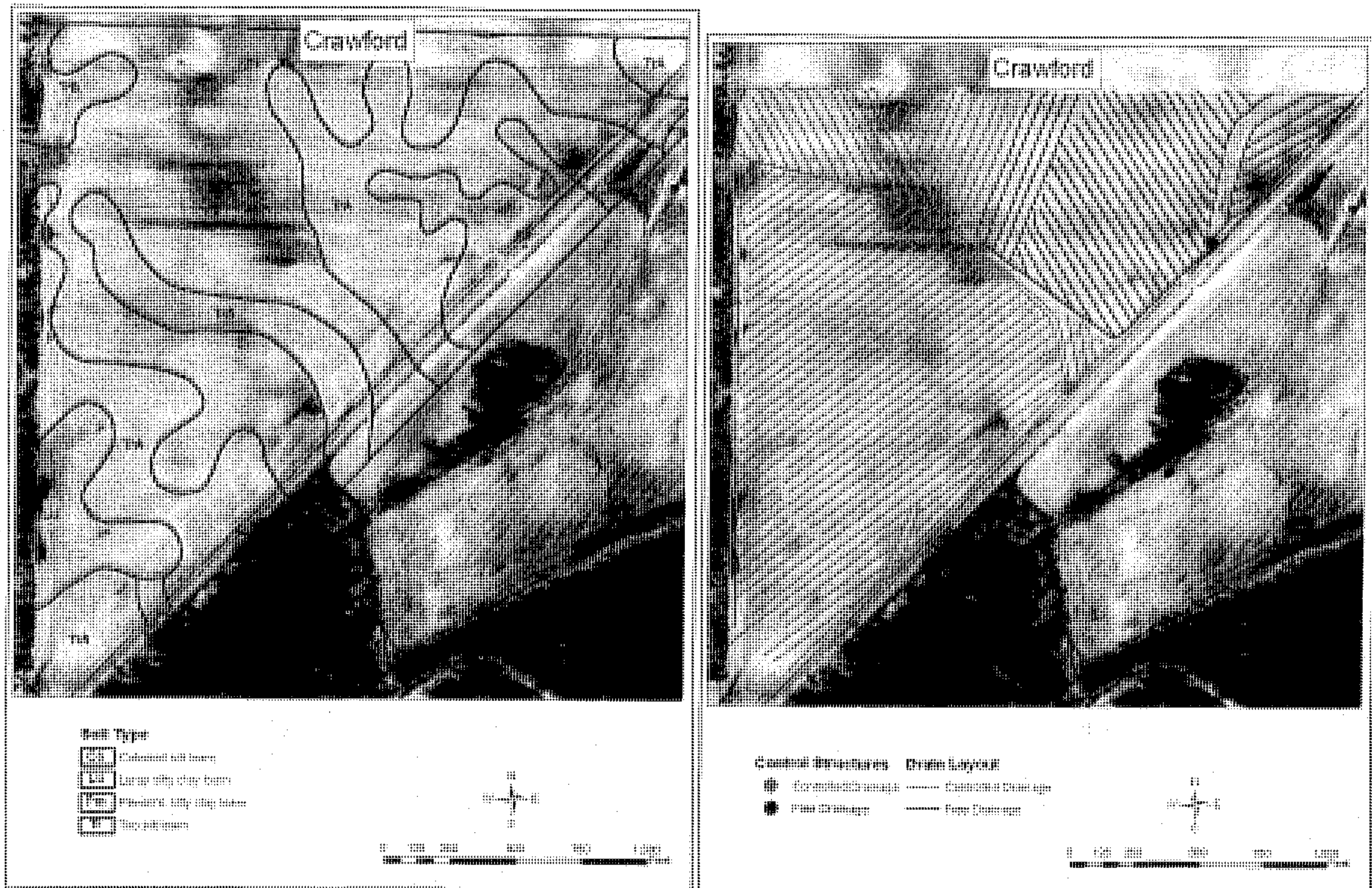


Figure 4- Crawford site soil and tile map.

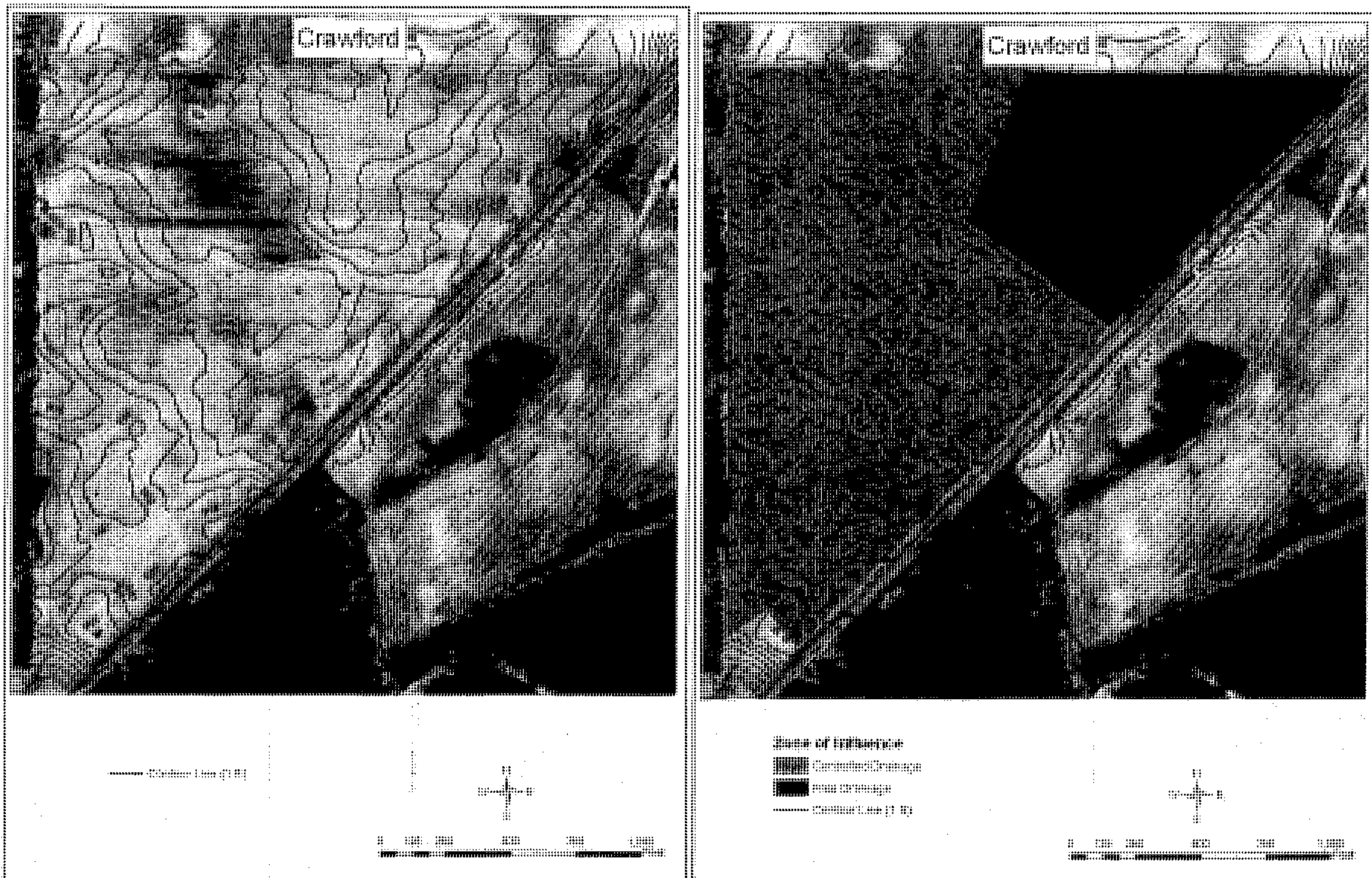


Figure 5- Crawford site topographic and aerial map.

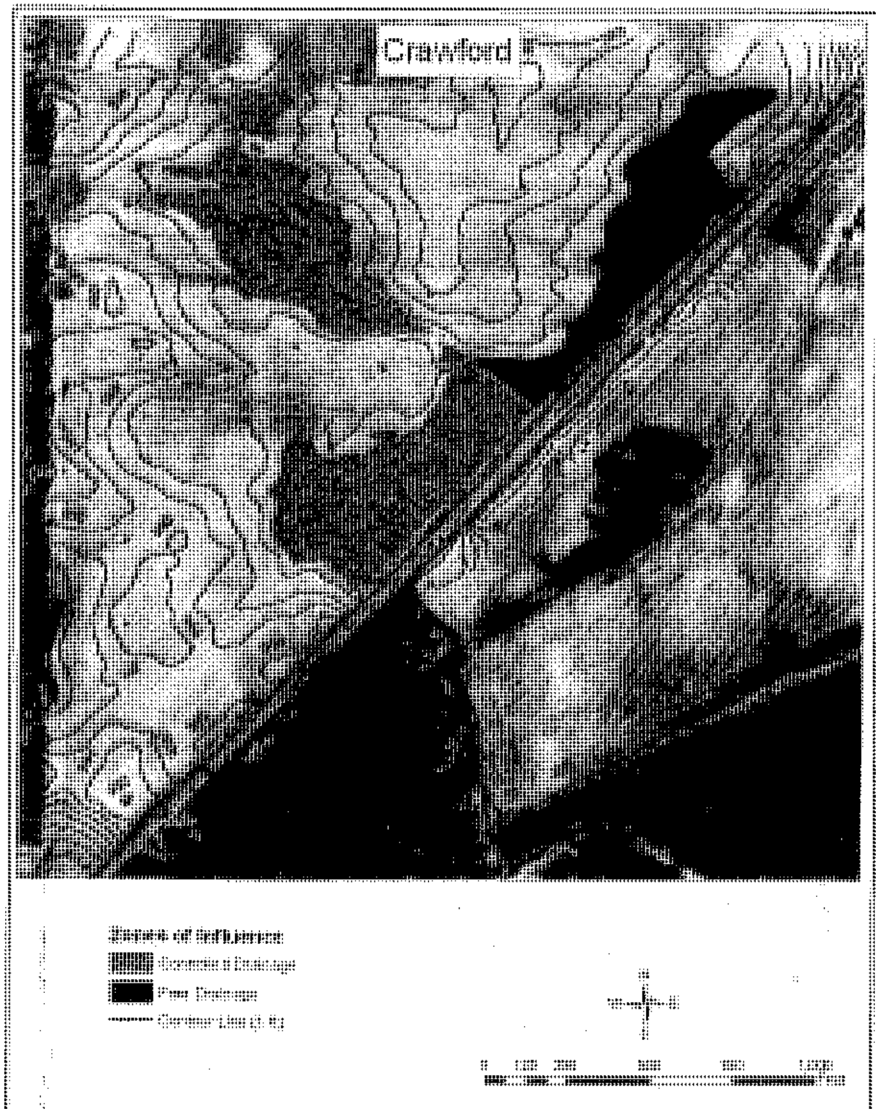
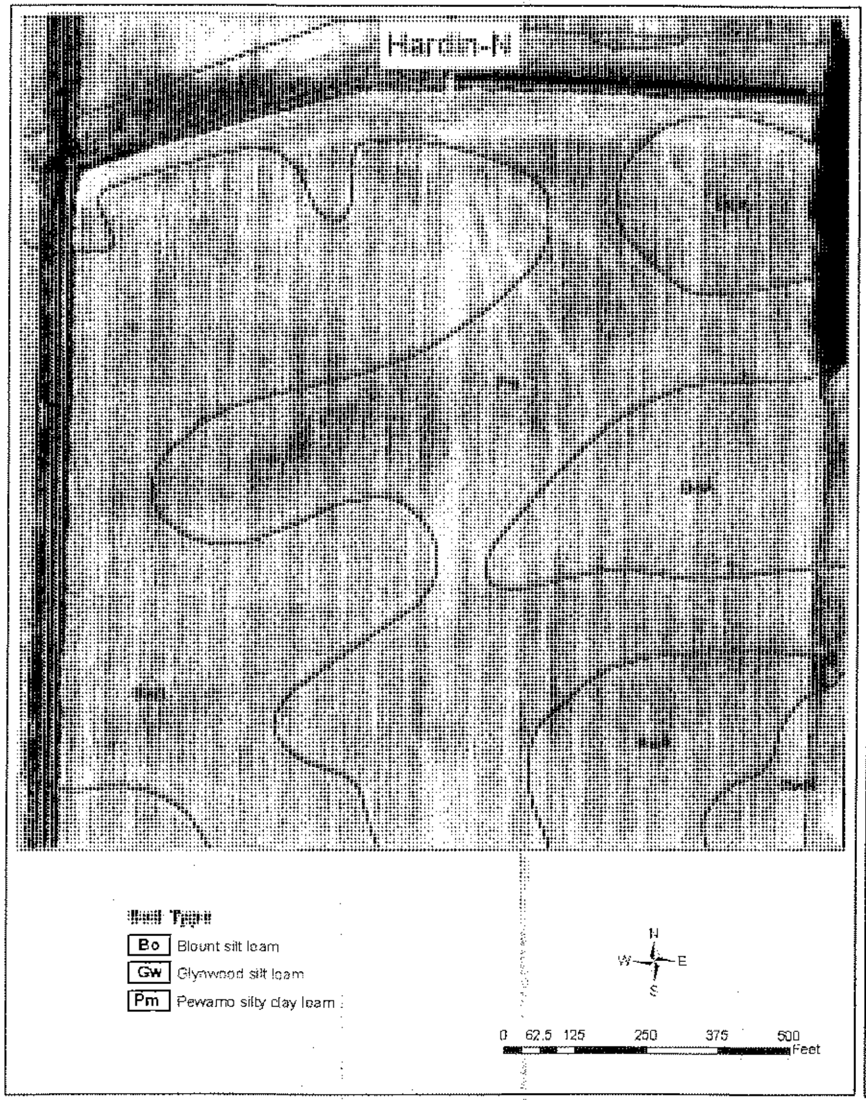


Figure 6- Crawford site zone of influence aerial map.



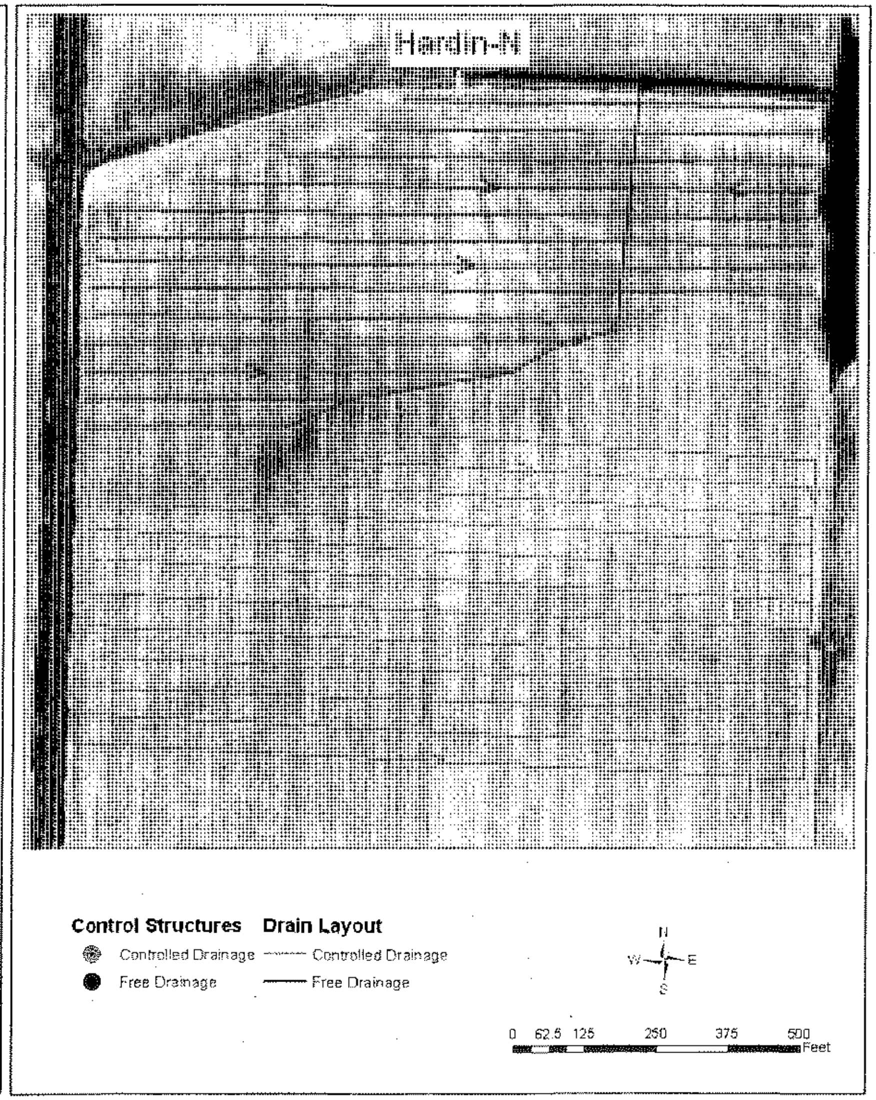
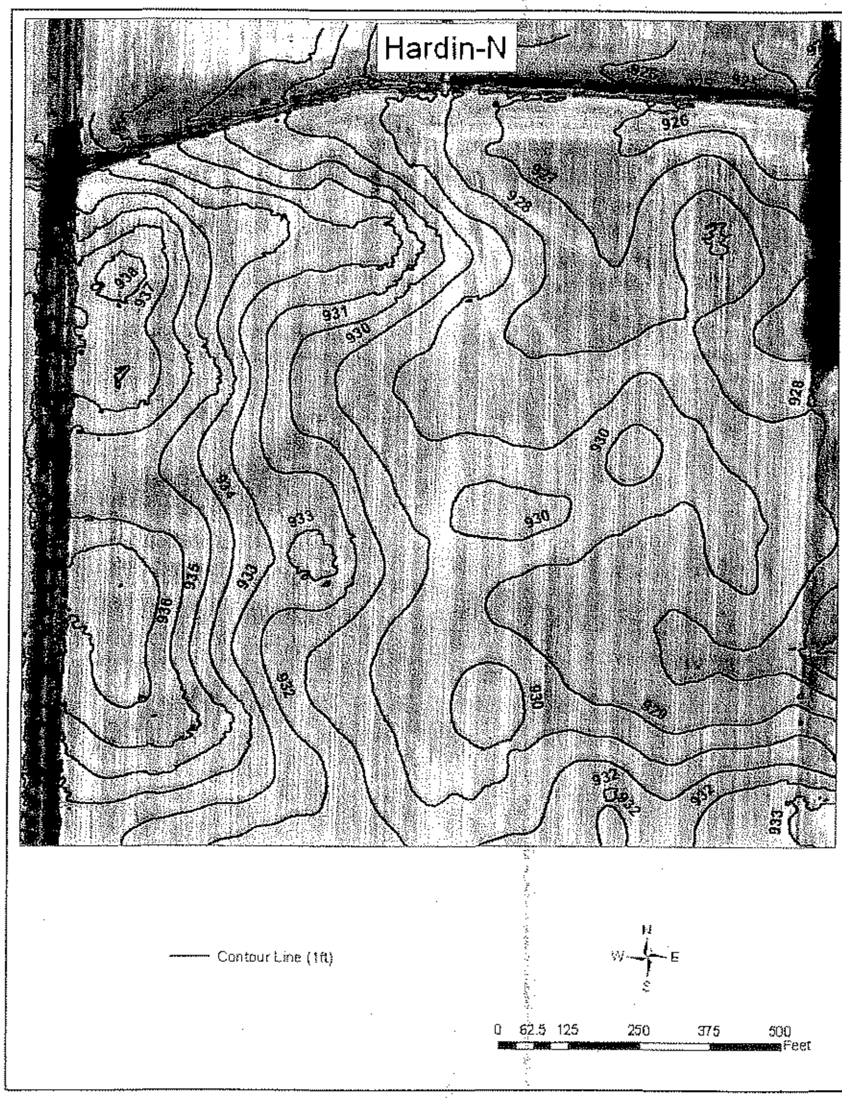


Figure 7- Hardin-N site soil and tile map.



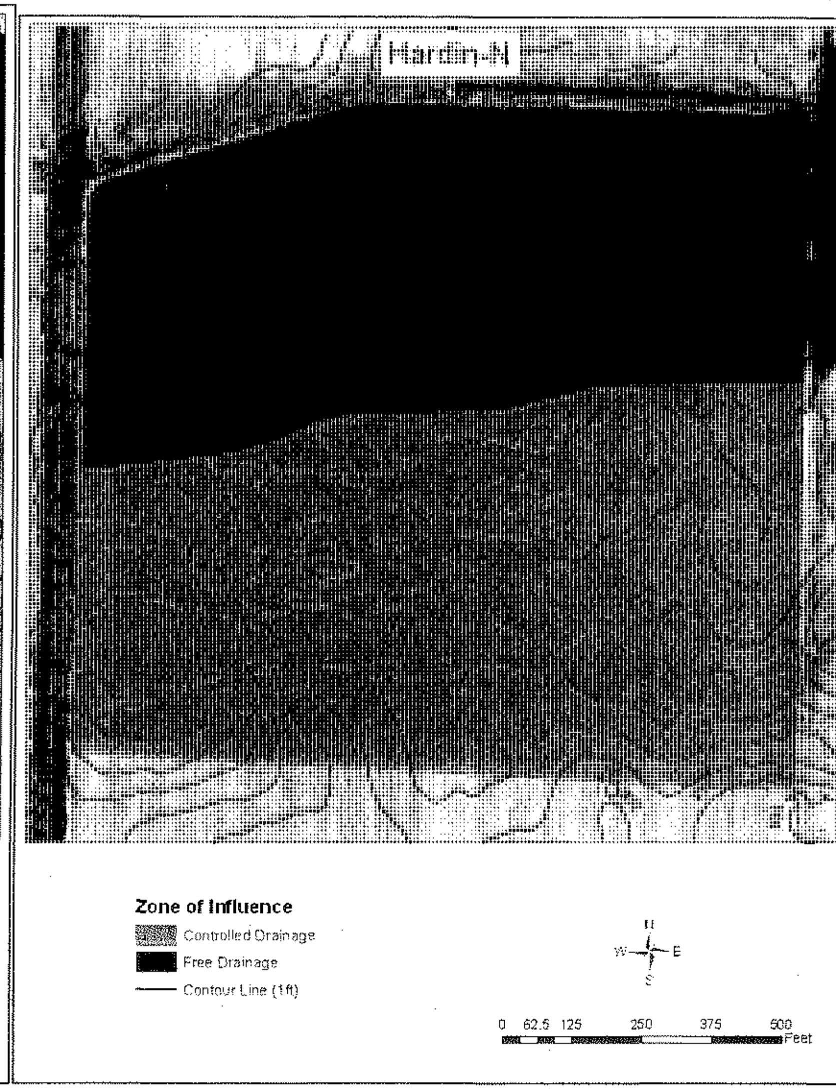


Figure 8- Hardin-N site topographic map and aerial map.

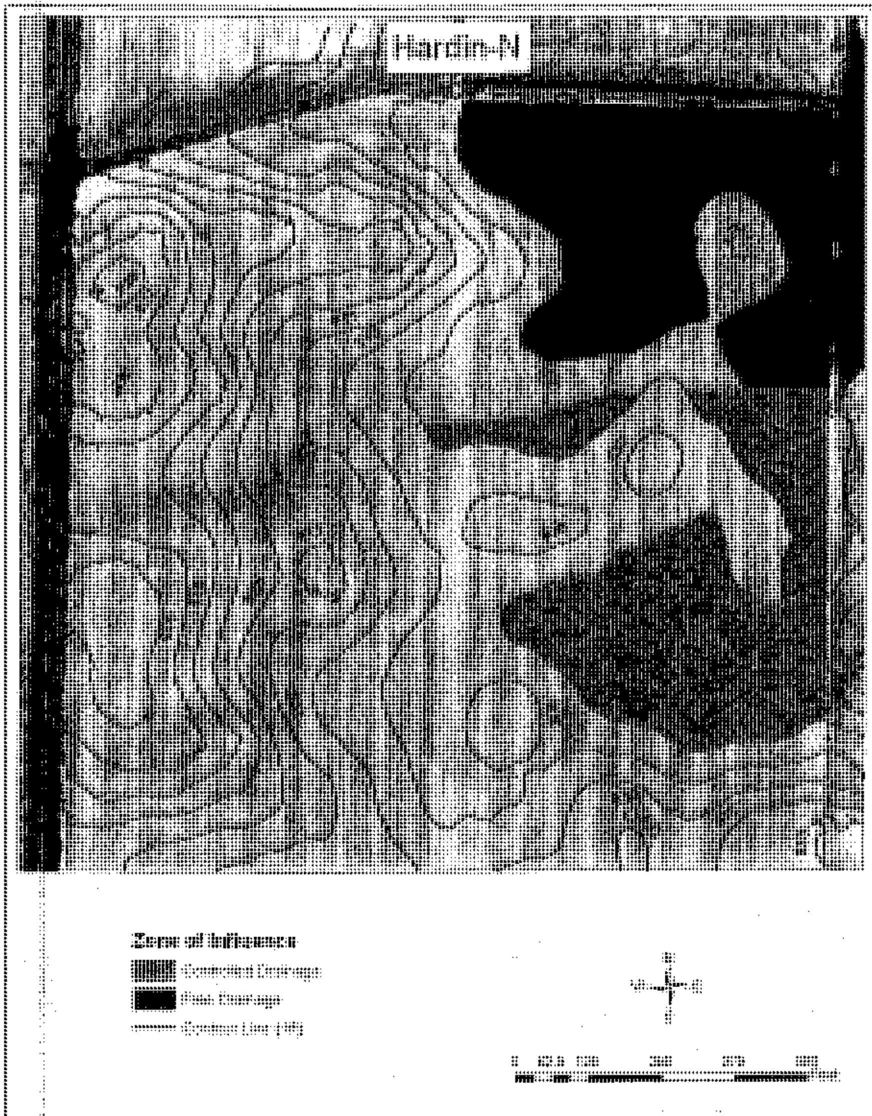


Figure 9- Hardin-N site zone of influence aerial map.

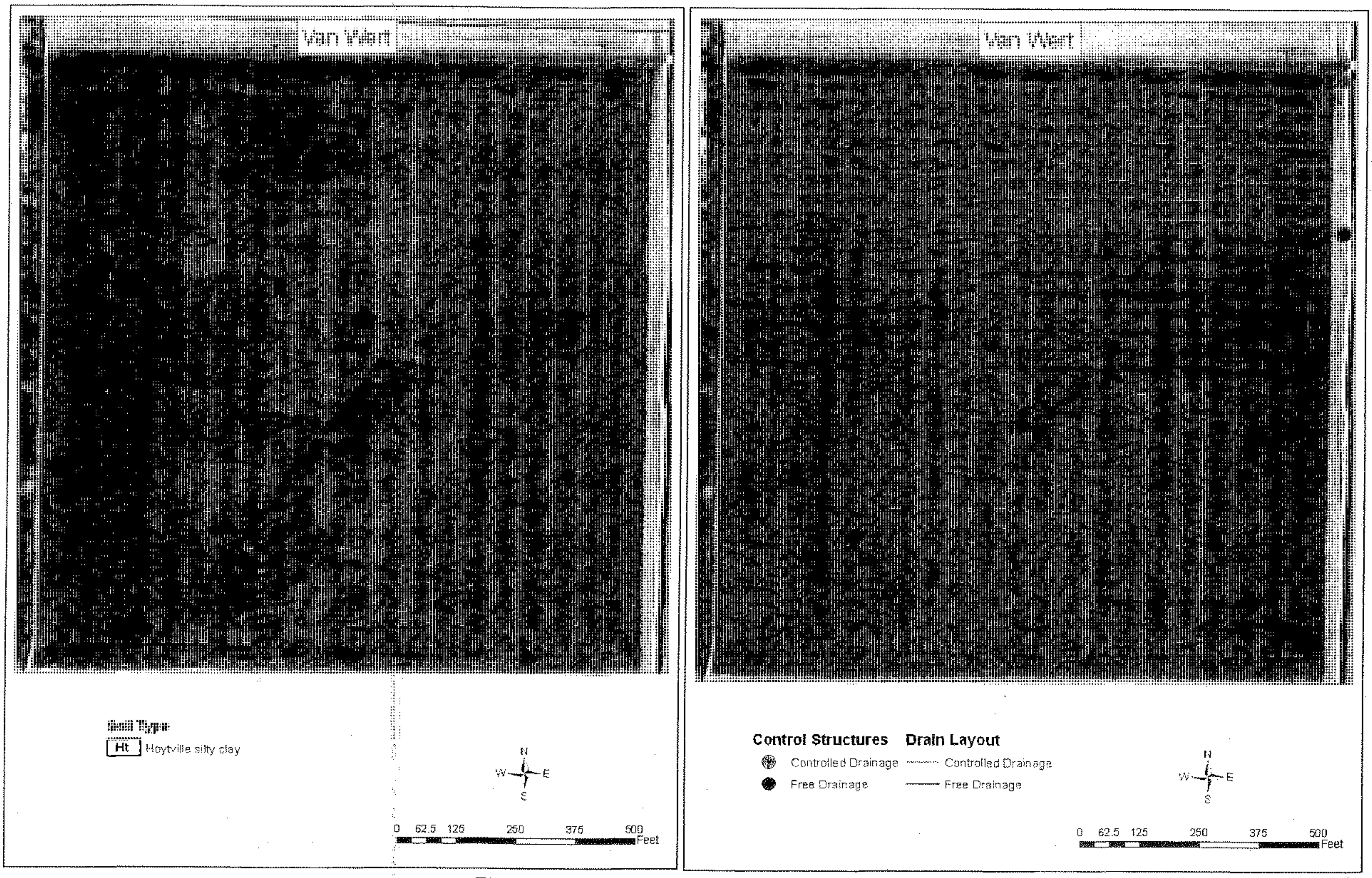


Figure 10- Van Wert site soil and tile map.

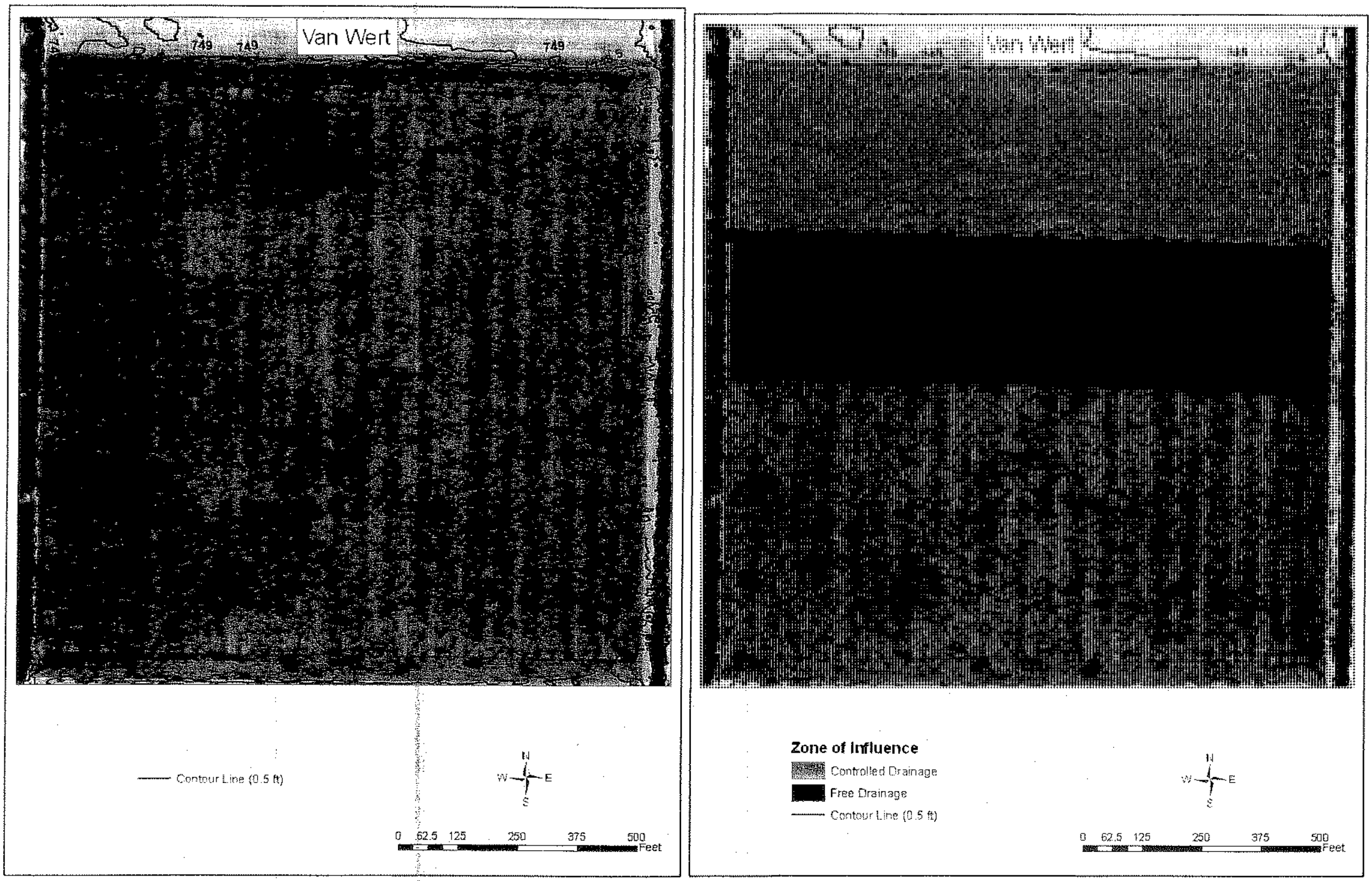


Figure 11- Van Wert site topographic and aerial map.

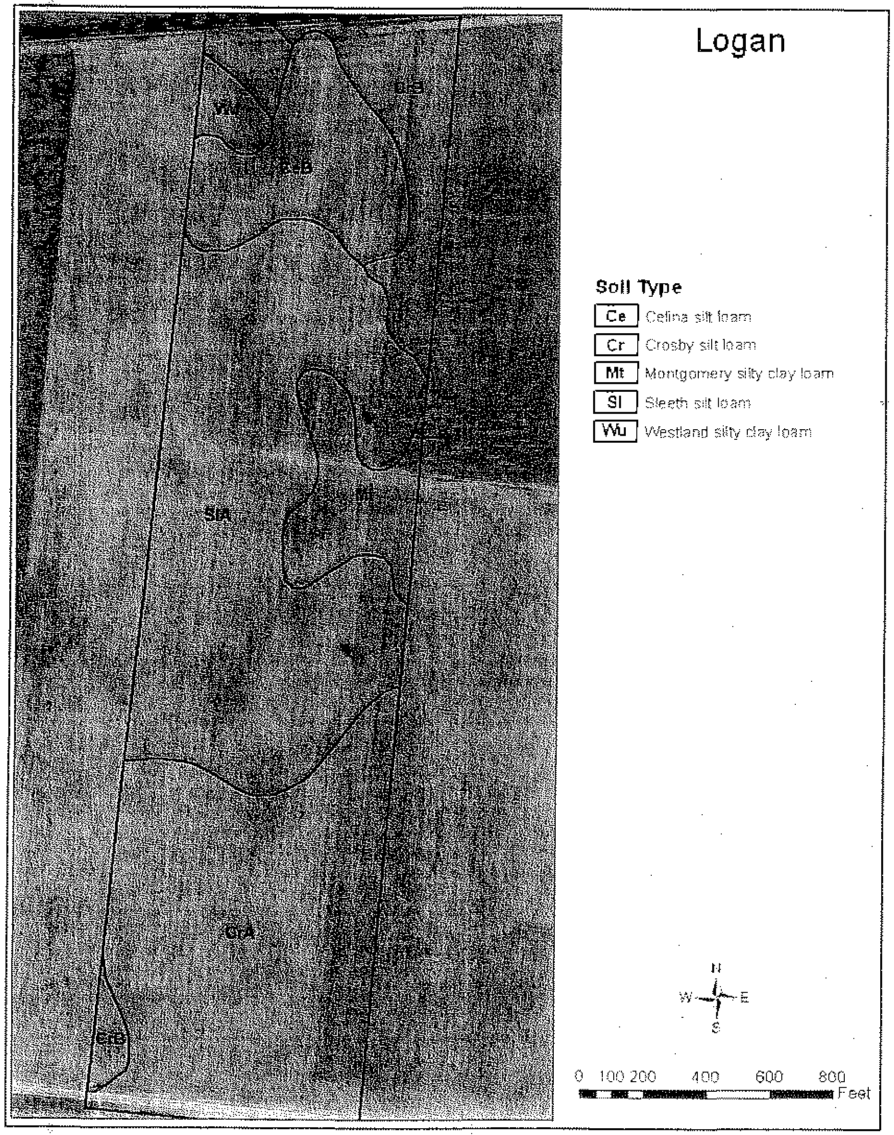


Figure 12- Logan site soil map.

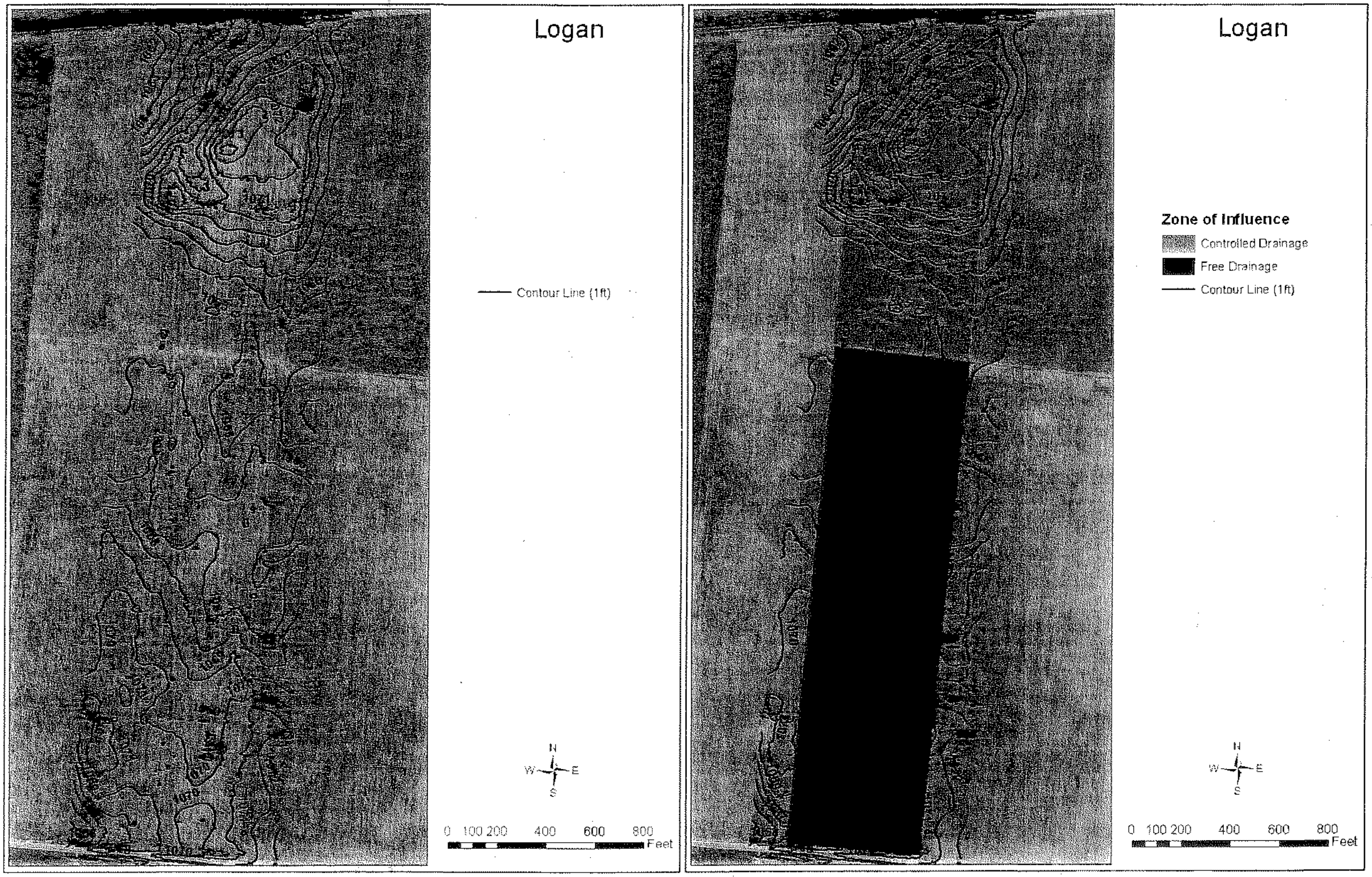


Figure 13- Logan site topographic and aerial map.

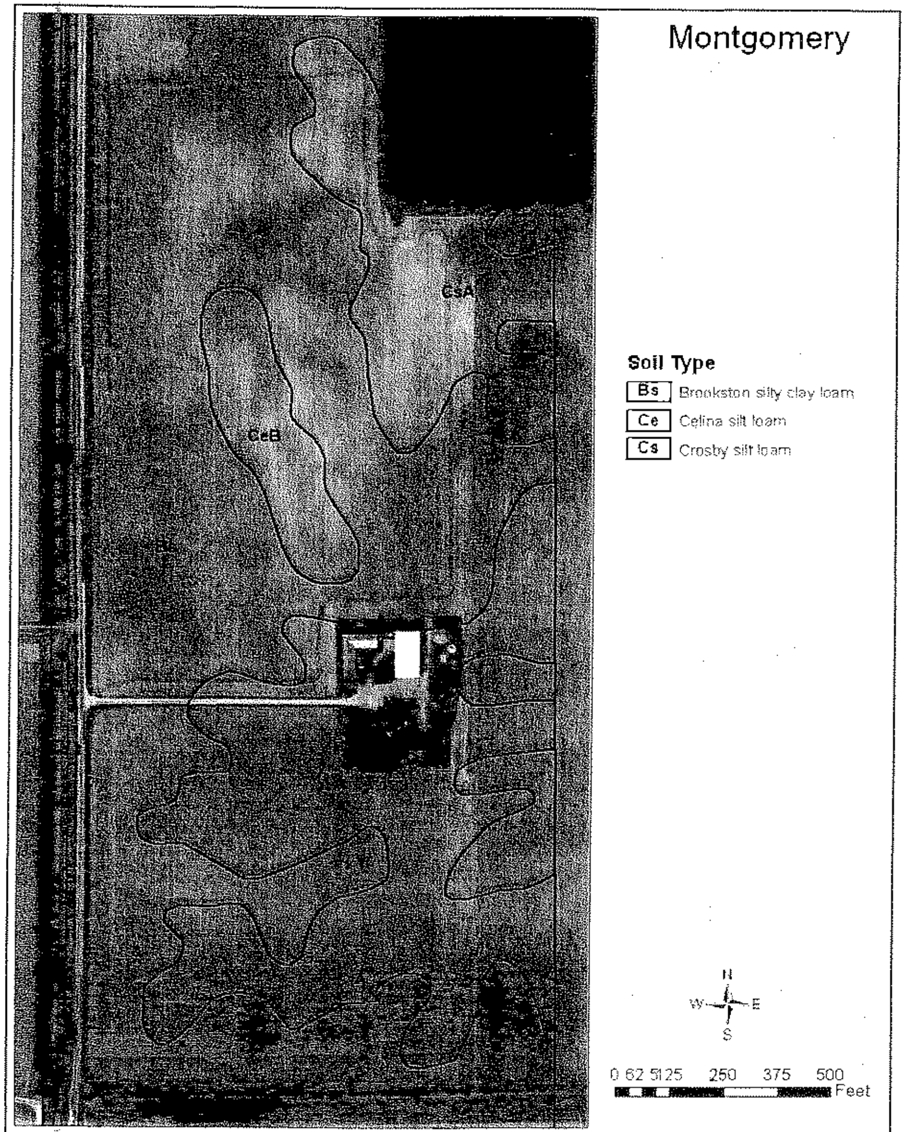
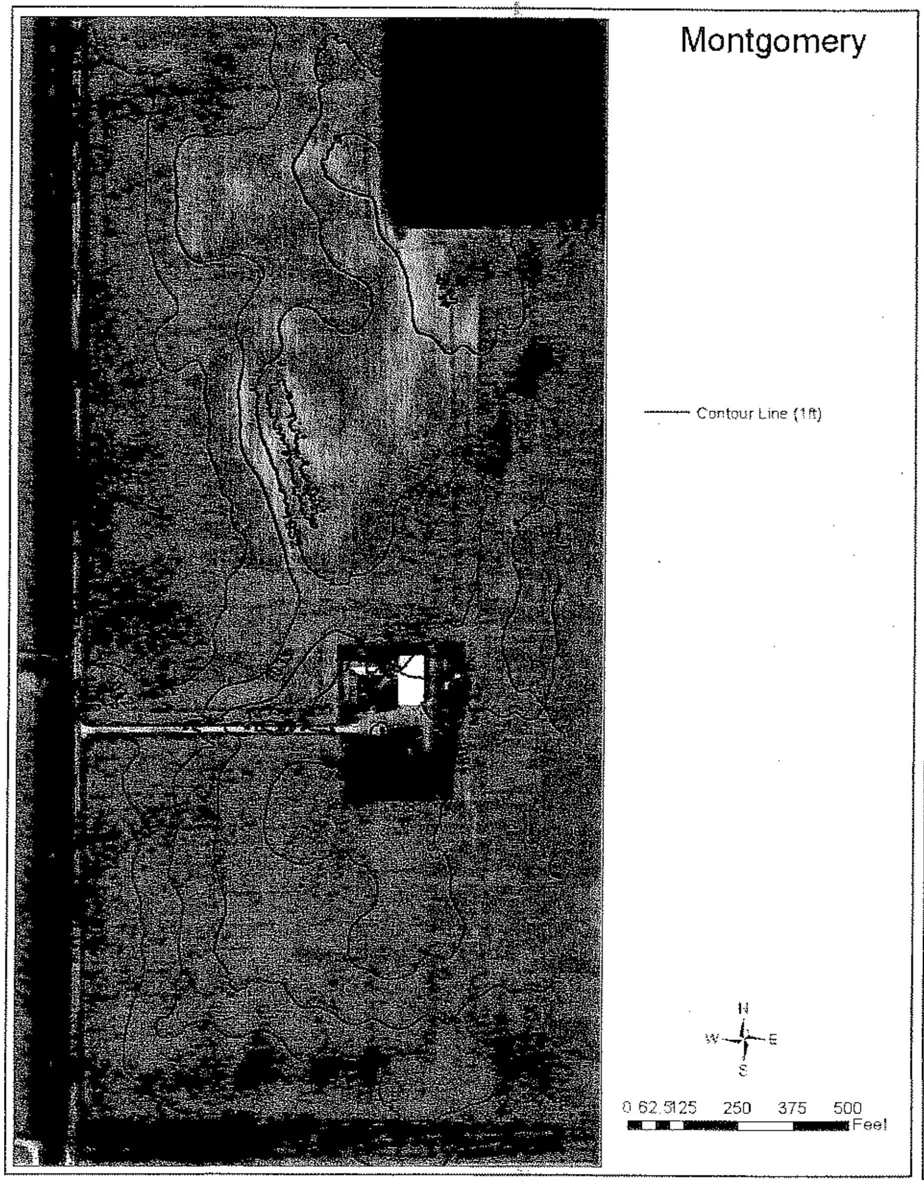


Figure 14- Montgomery site soil map.



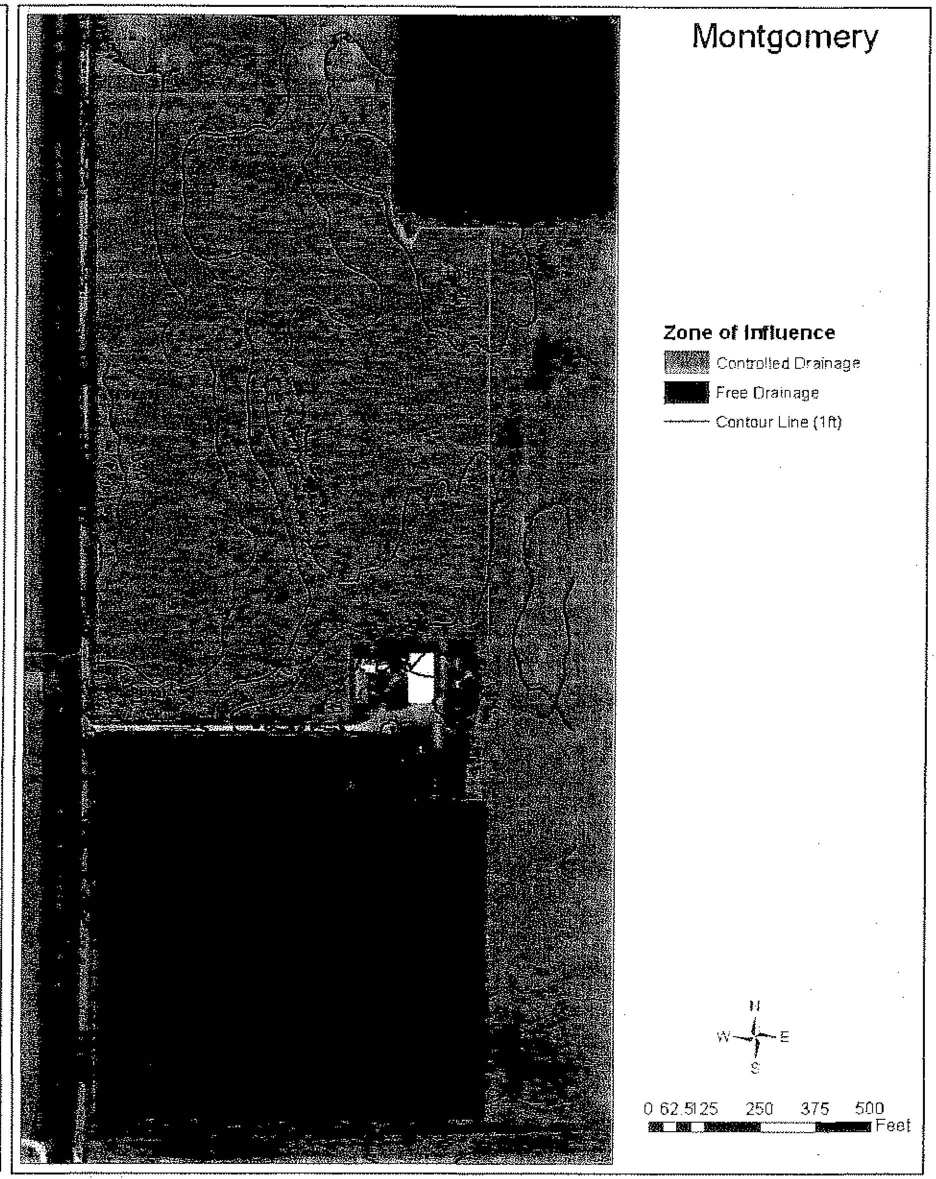


Figure 15- Montgomery site topographic and aerial map.

Water Management Plan

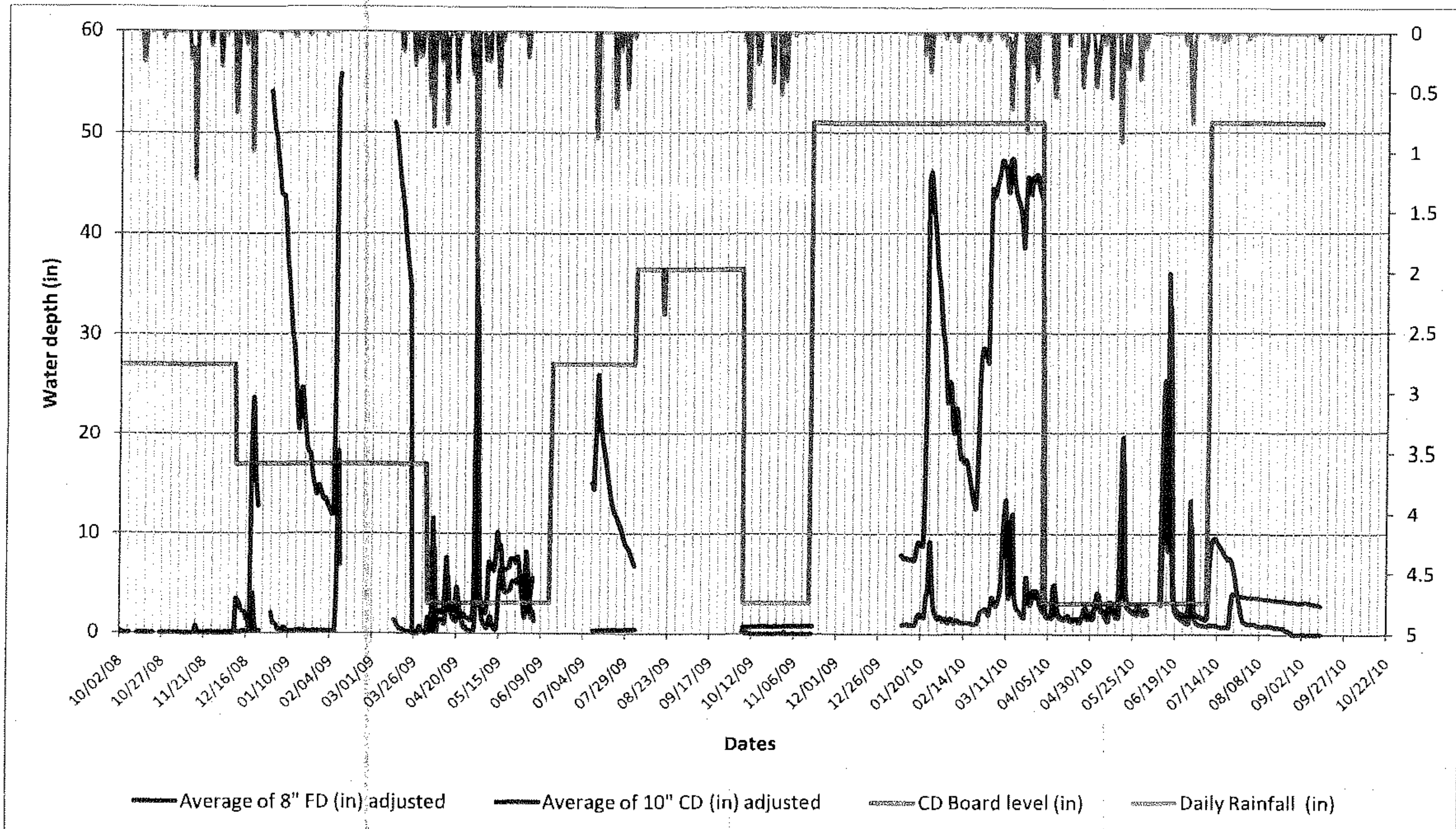


Figure 16- Summary of mean daily water depth and rainfall depth at the test site Auglaize-SE (10/08 - 09/10).

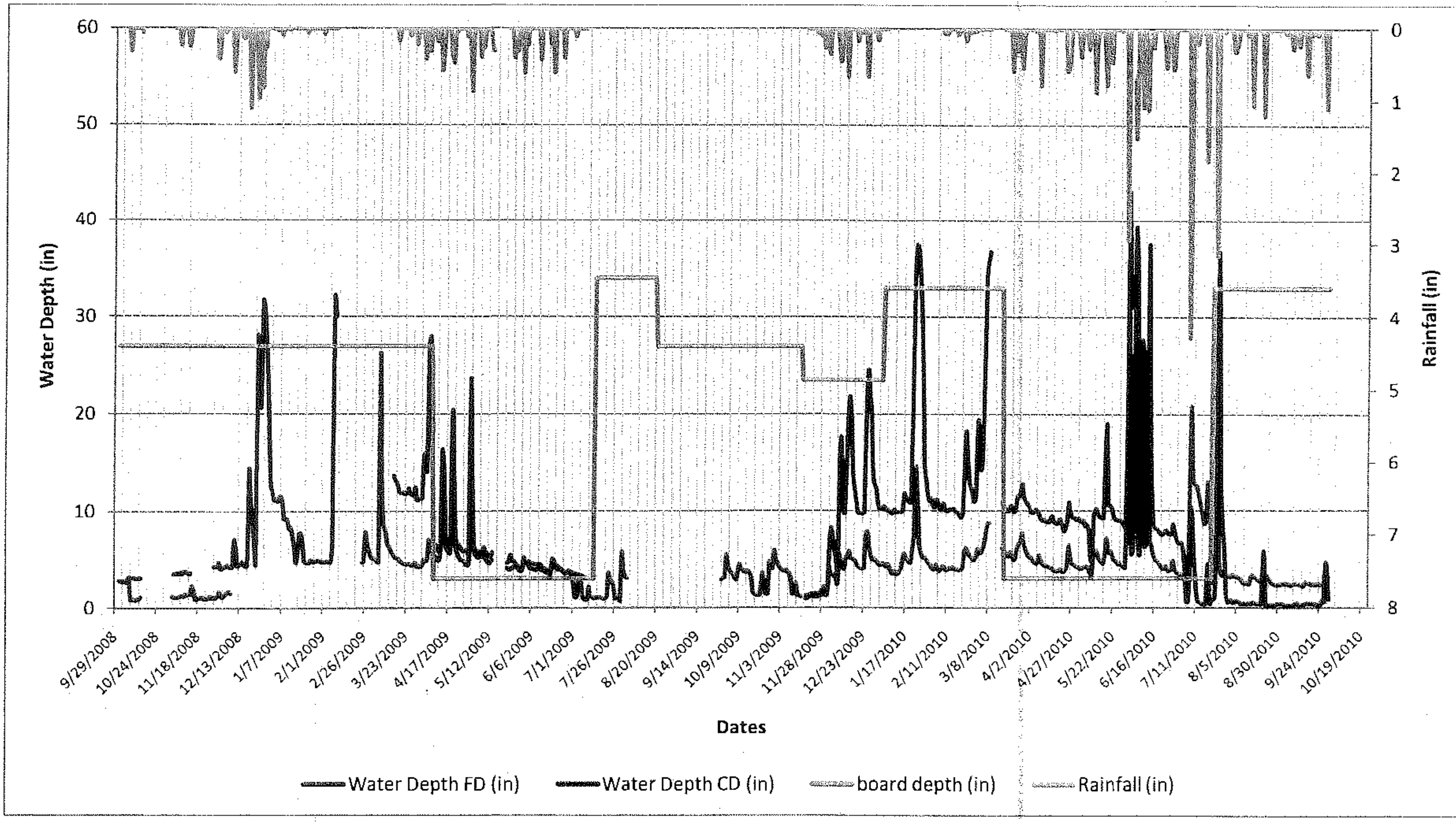


Figure 17- Summary of mean daily water and rainfall depth at the test site Crawford (09/08 - 10/10).

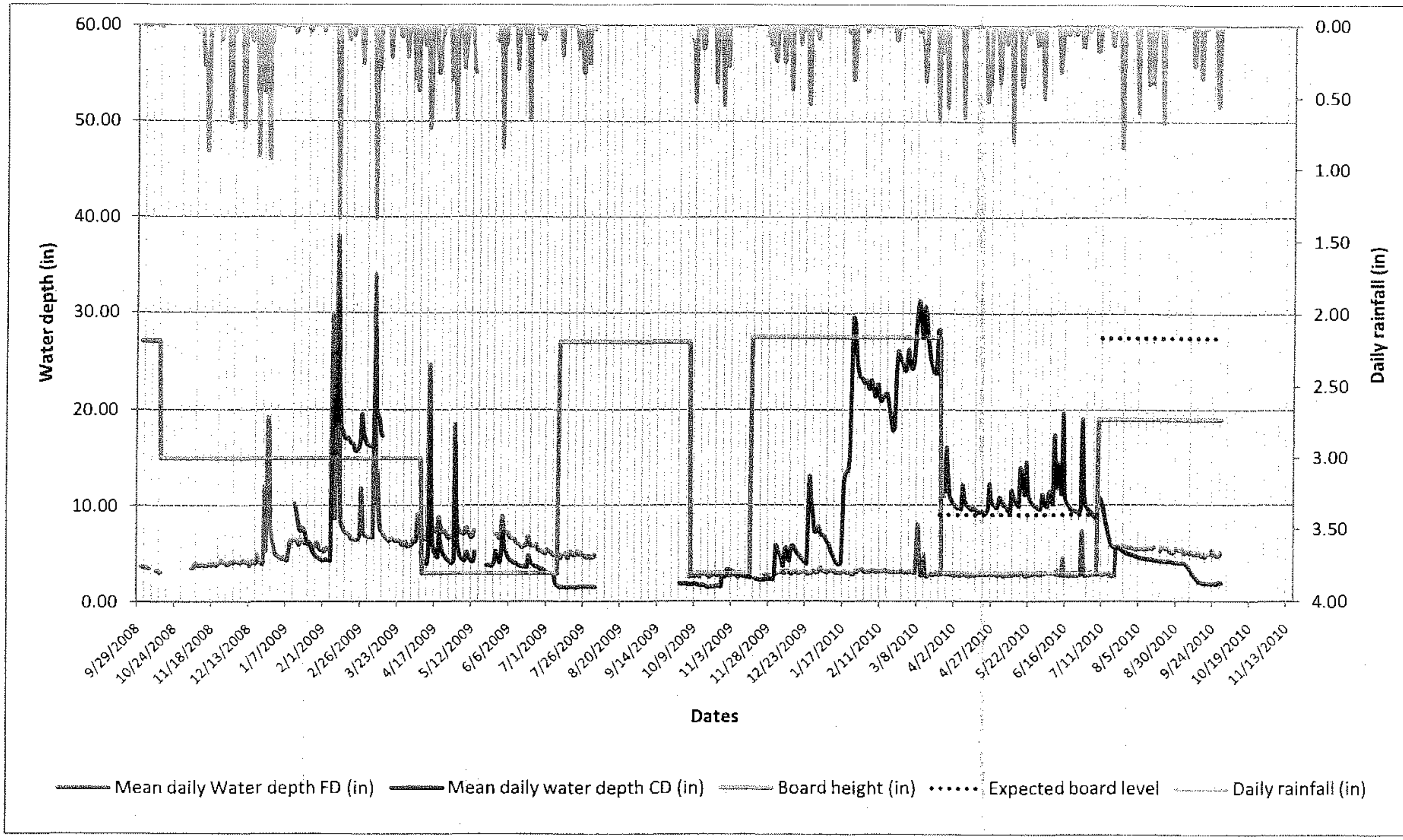


Figure 18- Summary of mean daily water depth and rainfall at the test site Hardin-N (10/08 - 09/10).

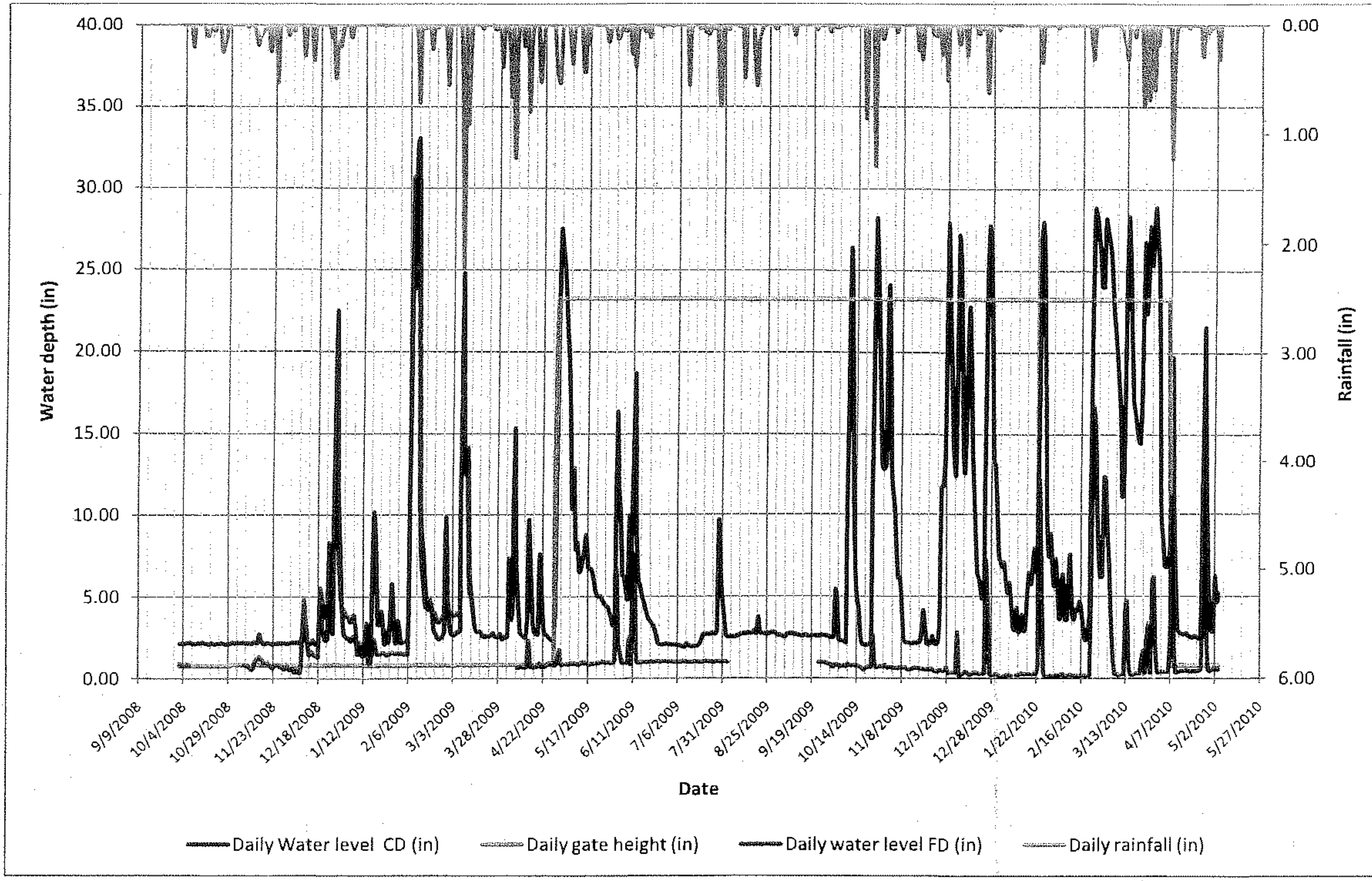


Figure 19- Summary of daily water and rainfall depths at the test site in Van Wert (10/08 - 05/10).

Cropping data

Table 2a- Cropping and management data for Auglaize-SE site.

	2008	2009
Crop	Corn	Soybeans
Variety	Dekalb 61-19	Pioneer 93Y80
Planting Date	5-1-08	4-24-09
Row Spacing (in)	30	10
Population	29,500	North side+end rowsat 300,000+195,000
Tillage	Disk Ripped in fall, Field Cultivated in Spring	No till
Nitrogen	Anhydrous Ammonia	
Fall N application Date		
Actual N (lb/acre)		
Pre-plant N application Date	4-18-08	
Actual N (lb/acre)	175 of 1pt of N-serve	
Post-plant N application Date	4-28-08,9-23-08	
Actual N (lb/acre)	200 N 5-1-08 Starter Fert	
Phosphorus Actual P (lb/acre)	100 of 18-46-0 50 of 21-0-0	
Potash Actual K (lb/acre)	Zinc 5 Auoil	
Herbicide Brand	Stead Fast Program	Sonic, Saluan, Durango, Surfact X-99
Herbicide Rate	$35/acre	Sonic 3oz, Saluan 1pt, X99 1pt, Durango 12oz
Insecticide Brand		
Insecticide Rate		
Harvest date	10-10-08	9-30-09

Table 2b- Cropping and management data for Crawford.

	2008	2009
Crop	Corn	Soybean
Variety		
Planting Date		
Row Spacing (in)	30	Drill
Population	33,500	210,000
Tillage	Conventional	No-till
Nitrogen		
Fall N application Date	---	
Actual N (lb/acre)		
Pre-plant N application Date		
Actual N (lb/acre)	60	
Post-plant N application Date		
Actual N (lb/acre)	100	
Phosphorus Actual P (lb/acre)	90	
Potash Actual K (lb/acre)	150	
Herbicide Brand	Lexar	
Herbicide Rate	2 1/2 qt	
Insecticide Brand		
Insecticide Rate		
Harvest date	11-6	

Table 2c-Cropping and management data for Hardin-N site.

	2007	2008	2009
Crop	Corn	Soybeans	Corn
Variety	Powell 5068	Powell PS346RRN	Powell 9192 RRVT3
Planting Date	5/6/2007	5/27/2008	5/13/2009
Row Spacing (in)	30	8	30
Population	31,000	210,000	32,000
Tillage	No till	No till	No till
Nitrogen			
Fall N application Date			
Actual N (lb/acre)			
Pre-plant N application Date			
Actual N (lb/acre)	176#10-34-0 45# 28%	24oz R-up weathermax	58# 6-23-6 170# 28%
Post-plant N application Date	5/25/2007		6/8/2009
Actual N (lb/acre)	170# NH#		150# NH3
Phosphorus Actual P (lb/acre)			
Potash Actual K (lb/acre)			
Herbicide Brand	1.5# Lexar 0.83# Atrazine 1qt Oil		2.5qt Keystone 1# Simazine 1qt Buccaneer
Herbicide Rate			
Insecticide Brand			
Insecticide Rate			
Harvest date			
Comments (hail, drought, heat, wind, etc.)			

Data in this table are gathered from a file from Justin McBride.

Table 2d- Cropping and management data for Site 4 (Van Wert).

	2008	2009
Crop	Beans	Wheat
Variety	AGI26RO3	Pioneer 25R56
Planting Date	5-22-08	9-25
Row Spacing (in)	15	15
Population	175,000	135lbs
Tillage	No-till	No-till with Kinze planter
Nitrogen		
Fall N application Date		09-25, 300#
Actual N (lb/acre)		9-26-20-4(sulfer)
Pre-plant N application Date		3-23
Actual N (lb/acre)		295#28-0-0
Post-plant N application Date		
Actual N (lb/acre)		
Phosphorus Actual P (lb/acre)		
Potash Actual K (lb/acre)		
Herbicide Brand	Bucuneer	
Herbicide Rate	1qt-1qt	
Insecticide Brand		
Insecticide Rate		
Harvest date	9-18-2008	7-8

Precipitation

Table 3- Monthly precipitation for all sites.

Month	State CIG sites			
	Auglaize-SE	Crawford	Hardin-N	Van Wert
	Total precipitation (Inches)			
Oct-08	0.48*	0.37*	0.01*	1.24*
Nov-08	2.29	1.05*	2.39	1.61
Dec-08	2.18*	4.85	4.15	2.01
Jan-09	0.14	0.2	0.14	0.13
Feb-09	0.03*	0.08*	2.06	1.85
Mar-09	0.87*	0.5*	2.36	4.81
Apr-09	4.13	3.62	3.8	6
May-09	3.61	2.98*	1.94*	1.97
Jun-09	0.02*	2.55	2.25	1.58
Jul-09	2.24*	0.11*	1.4	2.29
Aug-09	0.05*	*	0.03*	1.87
Sep-09	0*	*	*	0.31
Oct-09	2.74*	*	2.48*	2.62
Nov-09	0.03*	0.49*	0.32*	1.26
Dec-09	*	3.05	2.13	1.99
Jan-10	0.65*	0.01*	0.53	0.37
Feb-10	0.42	0.57*	0.25	0.51
Mar-10	2.77	1.55*	2.24	3.07
Apr-10	1.88	2.24	1.84	2.35
May-10	4.04	6.92	2.98	0.36*
Jun-10	1.53*	7.24	1.64*	*
Jul-10	0.44	9.92	1.74	*
Aug-10	0.05	3.1	2.35	*
Sep-10	0.08*	2.76	1.52	*

***- Missing data**

Table 4 shows the number of storms occurred at the field experimental sites, as well as the maximum and minimum storm depth, per class of storm.

At the experimental site in Auglaize County, the largest storm occurred in May 2009 and the smallest in June and July 2010. In Hardin County (McBride Farm), the largest storm occurred in November 2008 and smallest in May 2009. In Crawford County, the largest storm was in July 2010 and smallest in March 2009. In Van Wert County, the largest storm was in March 2009 and the smallest in March 2010.

Table 4- Classified number and depth of storms at the experimental sites.

Storm depth (in)		Auglaize-SE	Van-wert	Crawford	Hardin	Montgomery	Logan
1 and greater	Count	6	12	16	10	*	*
	Max	2.78	2.89	4.42	1.58	*	*
	Min	1.15	1	1.06	1	*	*
0.75 - 1	Count	9	5	11	9	*	*
	Max	0.99	0.9	0.98	0.98	*	*
	Min	0.75	0.83	0.79	0.76	*	*
0.5 - 0.75	Count	8	12	10	17	*	*
	Max	0.73	0.74	0.74	0.74	*	*
	Min	0.54	0.54	0.52	0.52	*	*
0.25 - 0.5	Count	13	13	14	16	*	*
	Max	0.48	0.49	0.49	0.47	*	*
	Min	0.26	0.26	0.25	0.25	*	*
0.1 - 0.25	Count	12	12	13	16	*	*
	Max	0.24	0.23	0.24	0.24	*	*
	Min	0.1	0.11	0.1	0.11	*	*

*- Data collection not yet established at these sites.

Departure from Normal

Table 5- Precipitation departure from normal at the Auglaize-SE site.

Months	Experimental site monthly	NOAA monthly	Departure from normal
		Precipitation (in)	
Oct-08	0.48*	2.32	*
Nov-08	2.29	2.95	-0.66
Dec-08	2.18*	2.65	*
Jan-09	0.14	2.17	-2.03
Feb-09	0.03*	2.08	*
Mar-09	0.87*	2.78	*
Apr-09	4.13	3.5	0.63
May-09	3.61	3.64	-0.03
Jun-09	0.02*	3.86	*
Jul-09	2.24*	4.43	*
Aug-09	0.05*	3.68	*
Sep-09	0*	2.76	*
Oct-09	2.74*	2.32	*
Nov-09	0.03*	2.95	*
Dec-09	*	2.65	*
Jan-10	0.65*	2.17	*
Feb-10	0.42	2.08	-1.66
Mar-10	2.77	2.78	-0.01
Apr-10	1.88	3.5	-1.62
May-10	4.04	3.64	0.4
Jun-10	1.53*	3.86	*
Jul-10	0.44	4.43	-3.99
Aug-10	0.05	3.68	-3.63
Sep-10	0.08*	2.76	*

*- missing data.
Negative departures mean less precipitation than normal, Positive departures mean more precipitation than normal.

Table 6- Precipitation departure from normal at the Crawford site.

Months	Experimental site monthly	NOAA monthly	Departure from normal
		Precipitation (in)	
Oct-08	0.37*	2.34	*
Nov-08	1.05*	3.08	*
Dec-08	4.85	2.75	2.1
Jan-09	0.2	2.28	-2.08
Feb-09	0.08*	1.95	*
Mar-09	0.5*	2.67	*
Apr-09	3.62	3.44	0.18
May-09	2.98*	4.01	*
Jun-09	2.55	4.35	-1.8
Jul-09	0.11*	4.37	*
Aug-09	*	3.95	*
Sep-09	*	3.11	*
Oct-09	*	2.34	*
Nov-09	0.49*	3.08	*
Dec-09	3.05	2.75	0.3
Jan-10	0.01*	2.28	*
Feb-10	0.57*	1.95	*
Mar-10	1.55*	2.67	*
Apr-10	2.24	3.44	-1.2
May-10	6.92	4.01	2.91
Jun-10	7.24	4.35	2.89
Jul-10	9.92	4.37	5.55
Aug-10	3.1	3.95	-0.85
Sep-10	2.76	3.11	-0.35

*- missing data.
Negative departures mean less precipitation than normal, Positive departures mean more precipitation than normal.

Table 7- Precipitation departure from normal at the Hardin-N site.

Months	Experimental site monthly	NOAA monthly	Departure from normal
		Precipitation (in)	
Oct-08	0.01*	2.11	*
Nov-08	2.39	2.84	-0.45
Dec-08	4.15	2.69	1.46
Jan-09	0.14	2.41	-2.27
Feb-09	2.06	2.04	0.02
Mar-09	2.36	2.7	-0.34
Apr-09	3.8	3.38	0.42
May-09	1.94*	3.82	*
Jun-09	2.25	3.59	-1.34
Jul-09	1.4	3.94	-2.54
Aug-09	0.03*	3.39	*
Sep-09	*	2.74	*
Oct-09	2.48*	2.11	*
Nov-09	0.32*	2.84	*
Dec-09	2.13	2.69	-0.56
Jan-10	0.53	2.41	-1.88
Feb-10	0.25	2.04	-1.79
Mar-10	2.24	2.7	-0.46
Apr-10	1.84	3.38	-1.54
May-10	2.98	3.82	-0.84
Jun-10	1.64*	3.59	*
Jul-10	1.74	3.94	-2.2
Aug-10	2.35	3.39	-1.04
Sep-10	1.52	2.74	-1.22

*- missing data points.
Negative departures mean less precipitation than normal, Positive departures mean more precipitation than normal.

Table 8- Precipitation departure from normal at the Van Wert site.

Months	Experimental site monthly	NOAA monthly	Departure from normal
		Precipitation (in)	
Oct-08	1.24 *	2.59	*
Nov-08	1.61	3.08	-1.47
Dec-08	2.01	2.78	-0.77
Jan-09	0.13	2.07	-1.94
Feb-09	1.85	1.85	0
Mar-09	4.81	2.63	2.18
Apr-09	6	3.47	2.53
May-09	1.97	3.81	-1.84
Jun-09	1.58	4.33	-2.75
Jul-09	2.29	3.9	-1.61
Aug-09	1.87	3.42	-1.55
Sep-09	0.31	2.93	-2.62
Oct-09	2.62	2.59	0.03
Nov-09	1.26	3.08	-1.82
Dec-09	1.99	2.78	-0.79
Jan-10	0.37	2.07	-1.70
Feb-10	0.51	1.85	-1.34
Mar-10	3.07	2.63	0.44
Apr-10	2.35	3.47	-1.12
May-10	0.36*	3.81	*

*- missing data.
Negative departures mean less precipitation than normal, Positive departures mean more precipitation than normal.

Crop Yield - Ohio MVRCD Project Sites

Table 1- Summary of the Ohio CIG regional sites in 2008

Site Name	Crop	Management	Zone Area (acre)	Average Yield (bu/ac)‡	Yield Increase (bu/ac)	Standard Error
Henry	Popcorn	Controlled D	38.3	59.2*	1.3	0.16
		Free D	35.0	58.0*		0.14
Auglaize-E	Soybean	Controlled D	19.8	43.6*	0.8	
		Free D	30.6	42.8*		
Hardin-NW	Corn	Controlled D	15.6	123.4*	19.8	0.50
		Free D	13.0	103.6*		0.53
Defiance	Soybean	Controlled D	19	29.4	1.0	0.58
		Free D	20	28.4		0.64

***- Means statistically significant using the two sample *t*-test at error rate α=0.05.**
‡- Popcorn yield is in lb/ac.

Table 2- Summary of the effective zone of the Ohio CIG regional sites in 2008

Site Name	Crop	Management	Effective Zone Area (acre)	Average Yield (bu/ac)	Yield Increase (bu/ac)	Standard Error
Hardin-NW	Corn	Controlled D	5.5	122.1*	20.2	0.10
		Free D	9.9	101.8*		0.13
Defiance	Soybean	Controlled D	5.1	31.9*	2.9	0.41
		Free D	1.2	29.0*		0.95

***- Means statistically significant using the two sample *t*-test at error rate α=0.05.**

Table 3- Summary of the Ohio CIG State sites in 2008

Site Name	Crop	Management	Zone Area (acre)	Average Yield (bu/ac)	Yield Increase (bu/ac)	Standard Error
Auglaize-SE	Corn	Controlled D	17.7	197.3*	20	0.53
		Free D	18.0	177.3*		0.85
Van Wert	Soybean	Controlled D	10.0	46.9	-1.5	0.28
		Free D	9.4	48.4		0.19
Hardin-N	Soybean	Controlled D	19.2	34.6*	2.9	0.22
		Free D	15.8	31.7*		0.26
Crawford	Soybean	Controlled D		No Data		
		Free D		No Data		

***- Means statistically significant using the two sample *t*-test at error rate α=0.05.**

Table 4- Summary of the effective zone of the Ohio CIG State sites in 2008

Site Name	Crop	Management	Effective Zone Area (acre)	Average Yield (bu/ac)	Yield Increase (bu/ac)	Standard Error
Hardin-N	Soybean	Controlled D	4.7	40.4*	7.5	0.26
		Free D	5.0	32.9*		0.49
Crawford	Soybean	Controlled D	11.1	No Data		
		Free D	5.0	No Data		

*- Means statistically significant using the two sample *t*-test at error rate α=0.05.

Ohio ADMC Regional Project Sites

Table 2. Crop and Yield Summary of Ohio CIG Regional Sites in 2008, Full Zone Means.

Site Name	County	Crop	Management	Zone Area (acre)	Average Yield over Full Zone (bu/ac)	Yield Increase (bu/ac)	Standard Error
Napoleon	Henry	Popcorn	Managed Drainage	38.3	57.96*	1.29	0.14
			Free Drainage	32.8	59.25*		0.16
Lakeview	Auglaize	Soybean	Managed Drainage	19.8	43.6*	0.8	11.16
			Free Drainage	30.6	42.8*		12.76
Dunkirk	Hardin	Corn	Managed Drainage	15.6	123.4*	19.8	0.50
			Free Drainage	13.0	103.6*		0.53
Defiance	Defiance	Soybean	Managed Drainage	19	29.4	1.0	0.58
			Free Drainage	20	28.4		0.64

***- Means statistically significant using the two sample *t*-test at error rate α=0.05.**

Table 2. Crop and Yield Summary of Ohio CIG Regional Sites in 2008, Zone Area-of-Influence Means.

Site Name	County	Crop	Management	Zone Area-of-Influence (acre)	Average Yield over Area-of-Influence (bu/ac)	Yield Increase (bu/ac)	Standard Error
Dunkirk	Hardin	Corn	Managed Drainage	5.5	122.1*	20.2	0.10
			Free Drainage	9.9	101.8*		0.13
Defiance	Defiance	Soybean	Managed Drainage	5.1	31.9*	2.9	0.41
			Free Drainage	1.2	29.0*		0.95

***- Means statistically significant using the two sample *t*-test at error rate α=0.05.**

Table 3. Crop and Yield Summary of Ohio CIG Regional Sites in 2009, Full Zone Means.

Site Name	County	Crop	Management	Zone Area (acre)	Average Yield over Full Zone (bu/ac)	Yield Increase (bu/ac)	Standard Error
Napoleon	Henry	Corn	Managed Drainage	38.3	214.1*	13.3	0.70
			Free Drainage	24.2	200.8*		0.69
Lakeview	Auglaize	Popcorn	Managed Drainage	19.8	49.5	0.1	11.16
			Free Drainage	30.6	49.4		12.76
Dunkirk	Hardin	Soybean	Managed Drainage	15.6	57.2*	2.2	0.23
			Free Drainage	13.0	54.9*		0.25
Defiance	Defiance	Corn	Managed Drainage	20.6	134.9*	4.0	0.39
			Free Drainage	19.4	130.9*		0.48

*- Means statistically significant using the two sample *t*-test at error rate α=0.05.

Table 4. Crop and Yield Summary of Ohio CIG Regional Sites in 2009, Zone Area-of-Influence Means.

Site Name	County	Crop	Management	Zone Area-of-Influence (acre)	Average Yield over Area-of-Influence (bu/ac)	Yield Increase (bu/ac)	Standard Error
Dunkirk	Hardin	Soybean	Managed Drainage	5.5	58.6*	1.8	0.35
			Free Drainage	9.9	56.8*		0.43
Defiance	Defiance	Corn	Managed Drainage	5.1	138.2*	8.1	0.90
			Free Drainage	1.2	130.1*		2.31

*- Means statistically significant using the two sample *t*-test at error rate α=0.05.

Ohio CIG Regional Sites

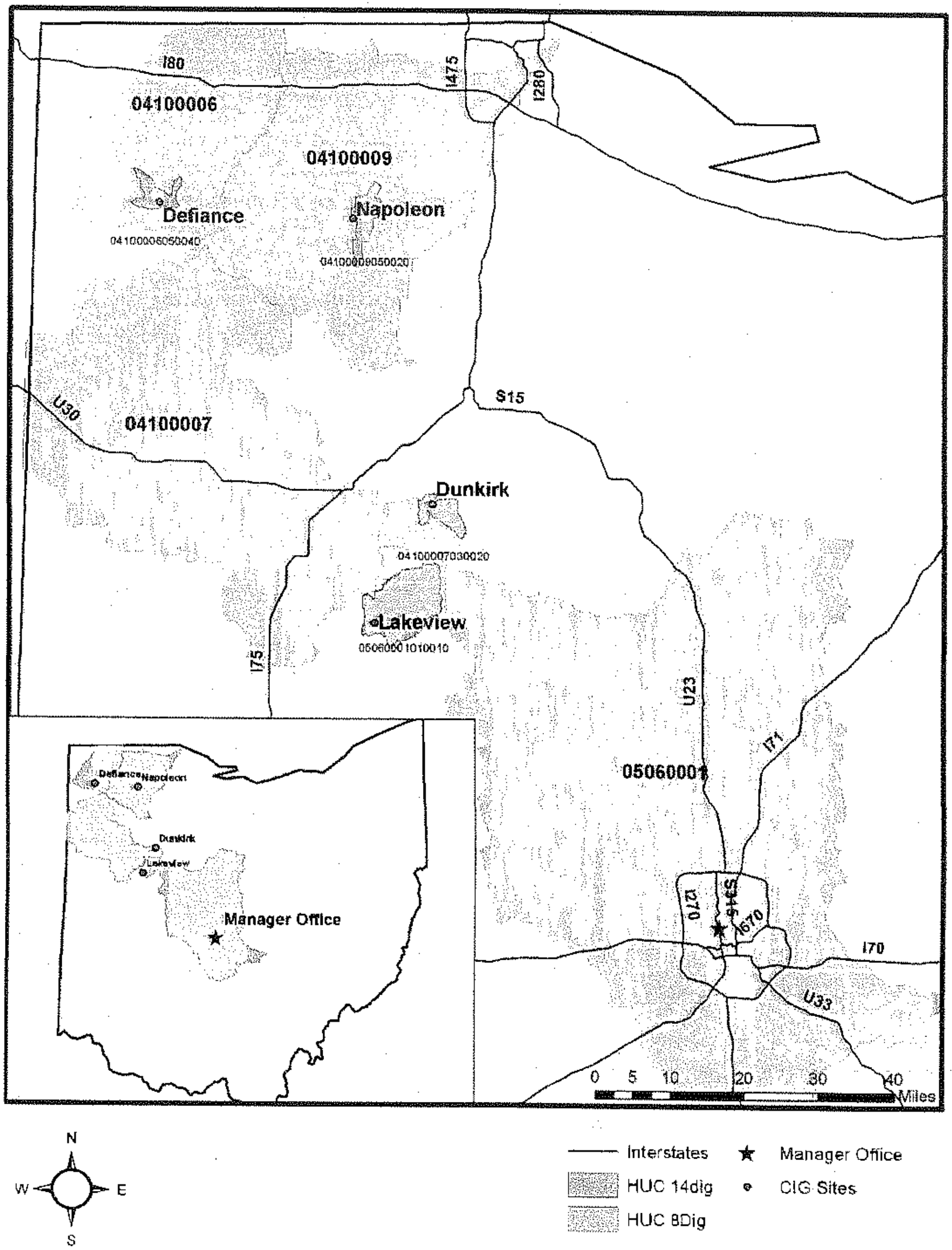


Table 1. Ohio site descriptions.

Sites	Site 1	Site 2	Site 3	Site 4
Site Name	**Defiance**	**Napoleon**	**Dunkirk**	**Lakeview**
Managed drainage (ac)	20	38	16	20
Conventional drainage (ac)	19	35	13	30
Dominant soil types	Paulding clay; Roselms silty clay	Mermill loam, clay loam	Blount silt loam; Pewamo silty clay loam; Mf	Mermill clay loam
Watershed name	Tiffin River	Lower Maumee River	Auglaize River	Upper Scioto River
14-Digit HUC	4100006050040	4100009050020	4100007030020	5060001010010
30-year precipitation average, in (record)	35.2 (1971-2000)	34.7 (1961-1990)	35.2 (1971-2000)	38.7 (1971-2000)
Subsurface drainage system installation year	2004 w/wtcs retrofit in 2001	Existing clay tile, updated with cpt in 2005 w/wtcs retrofit in 2007	2006-2007 w/wtcs retrofit in 2007	1988-1989; w/wtcs retrofit in 2007
Depth of ssd pipe, in	2.5-3.5	2.5-3.5	2.5-3.5	3.0-3.5
Drainage coefficient, in	3/8	3/8	3/8	3/8 or 1/2
SSD spacing, ft	40	40' avg	20	50
New or retrofit system	Retrofit	Retrofit	New	Retrofit
Water table control structure installation year	1st one previous to 2007; 2nd one in 2007	1st one previous to 2007; 2nd one in 2007/2008	Both in 2007	Both in 2007
Laterals on the contour (Yes or No)?	No	0% slope, Yes	No	0% slope, Yes

Figure 1. Defiance site soil map.

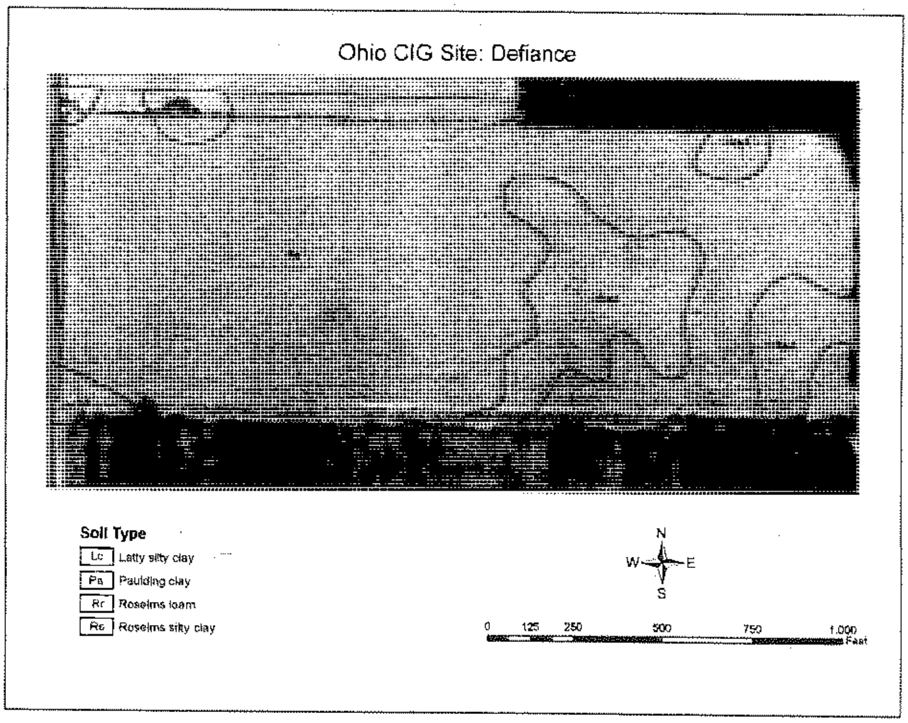


Figure 2. Defiance site tile map.

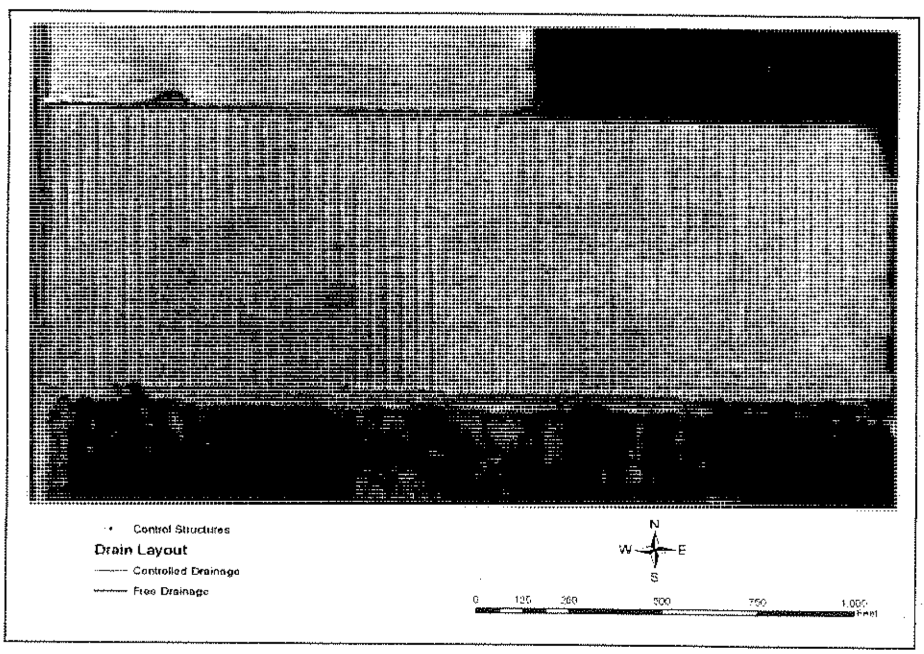


Figure 3. Defiance site topographical map.

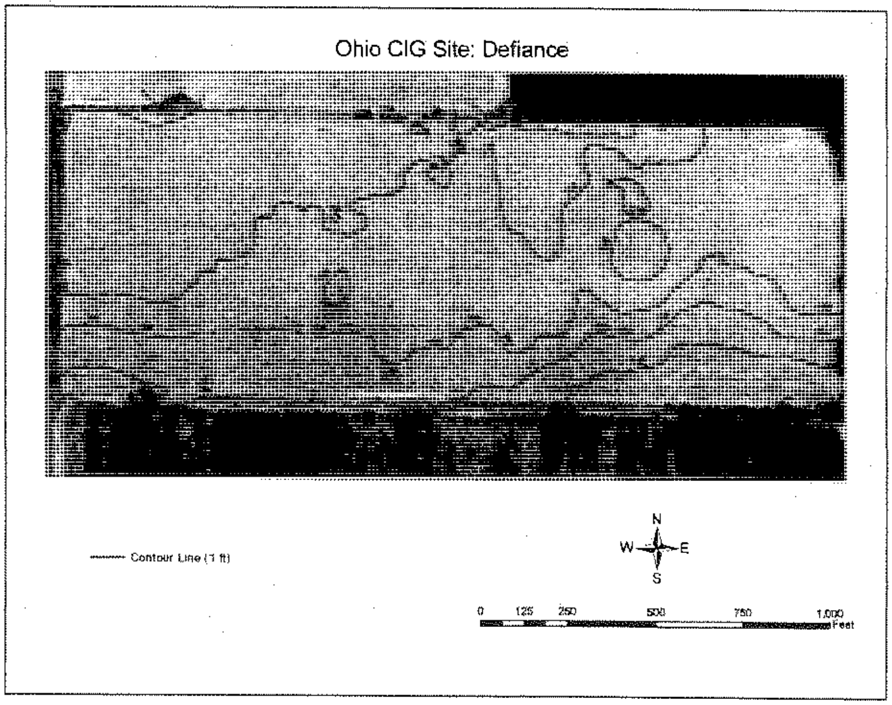


Figure 4. Defiance site aerial map.

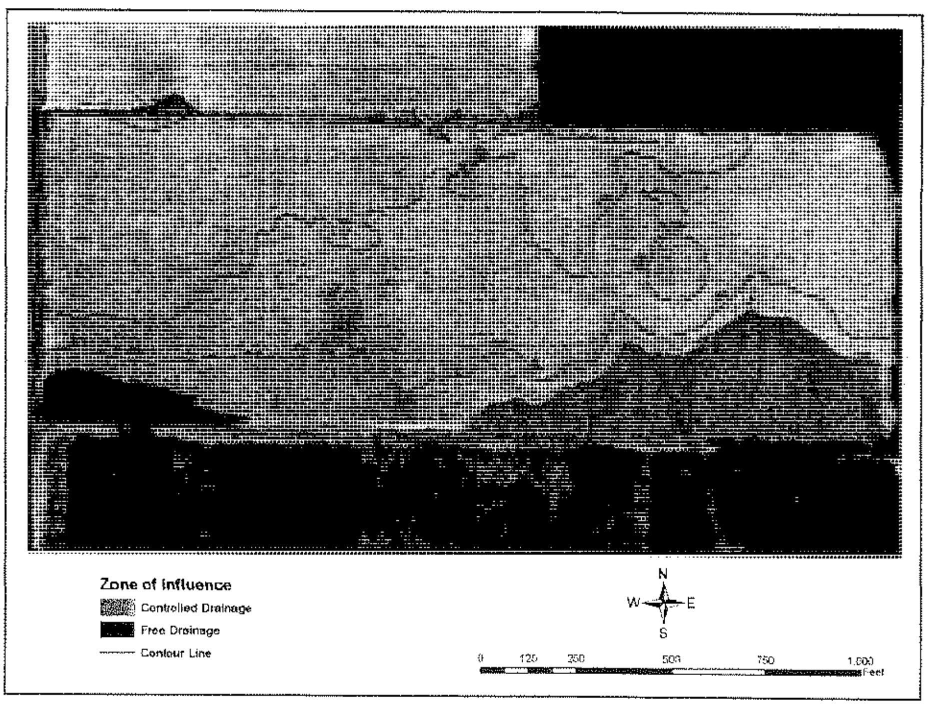


Figure 5. Napoleon site soil map.

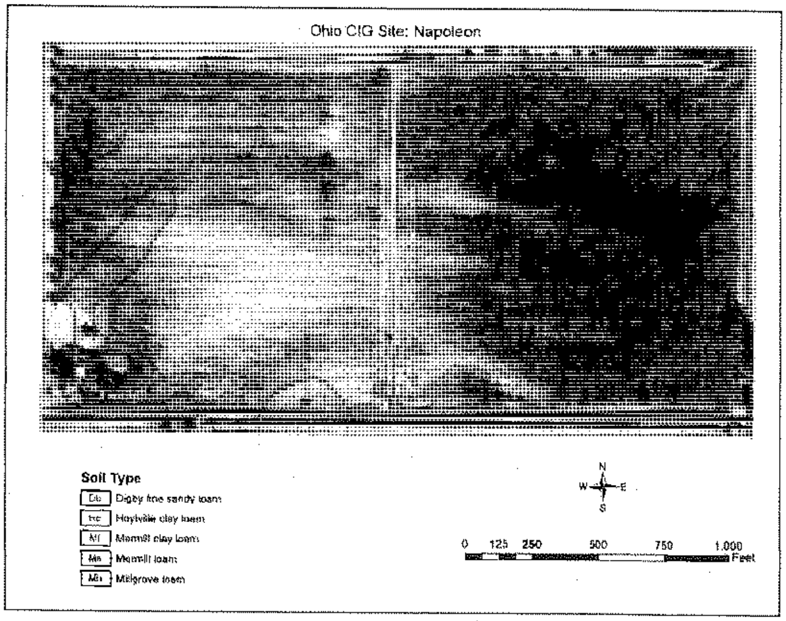


Figure 6. Napoleon site tile map.

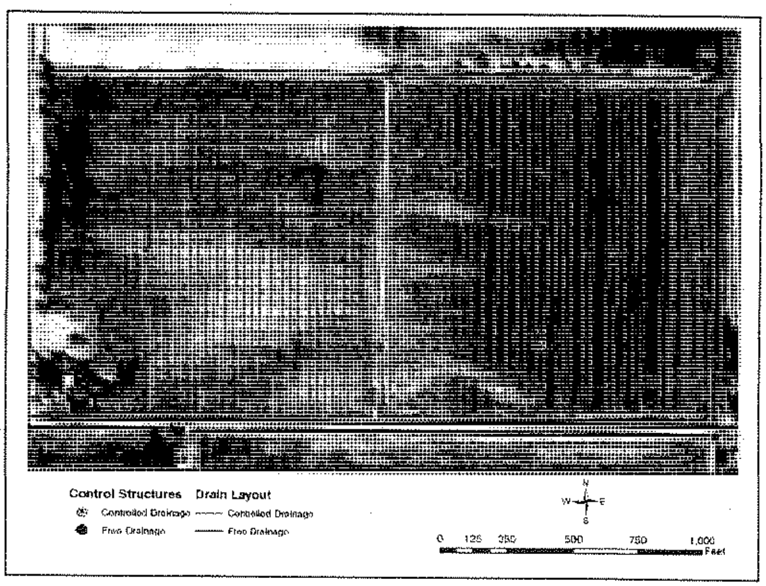


Figure 7. Napoleon site topographical map.

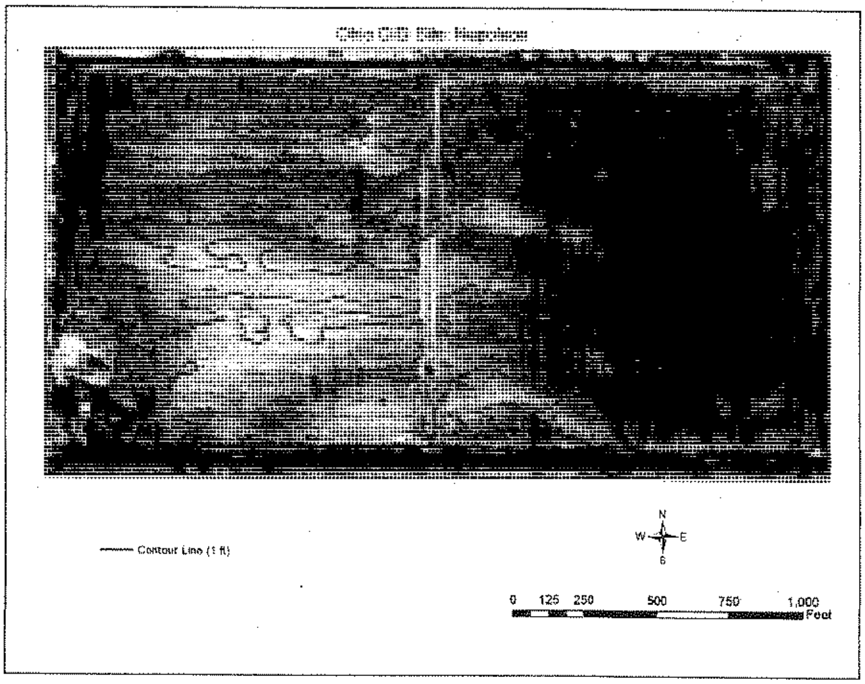


Figure 8. Napoleon site aerial map.

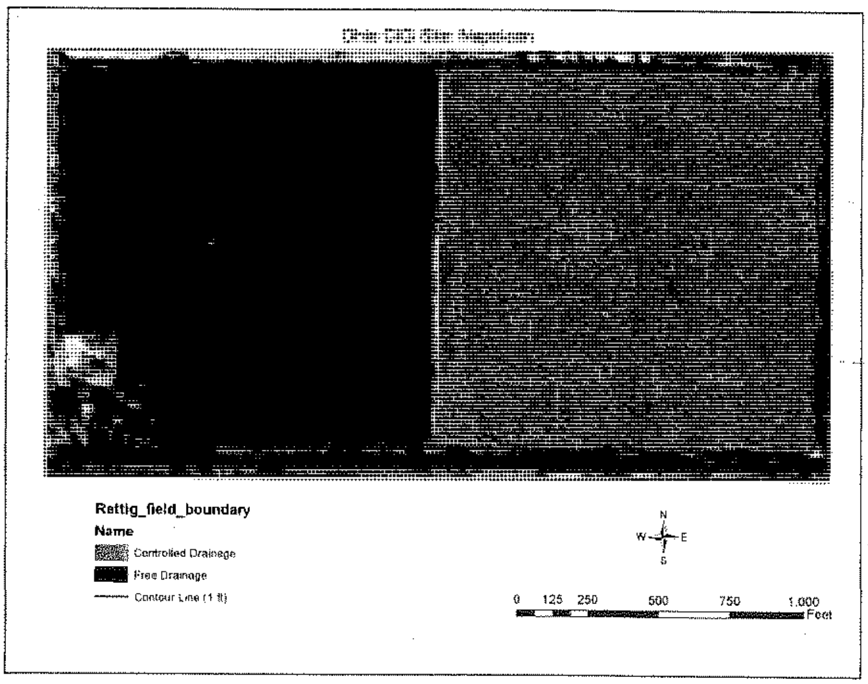


Figure 9. Dunkirk site soil map.

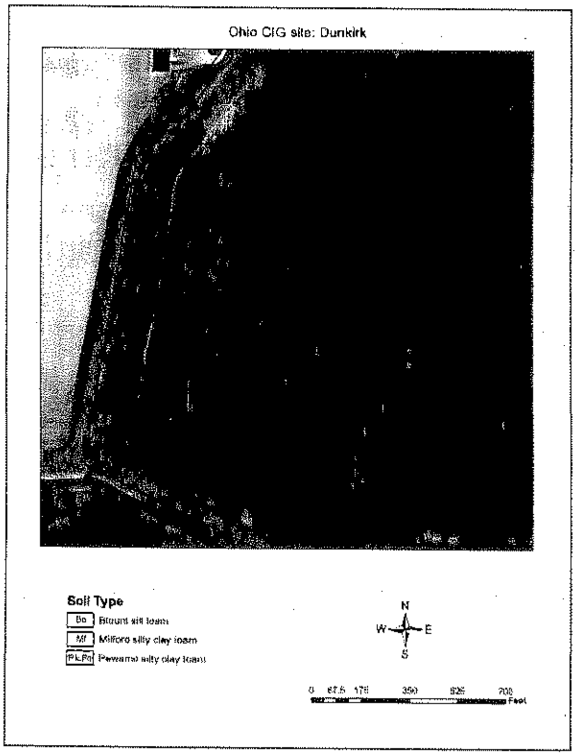


Figure 10. Dunkirk site tile map.

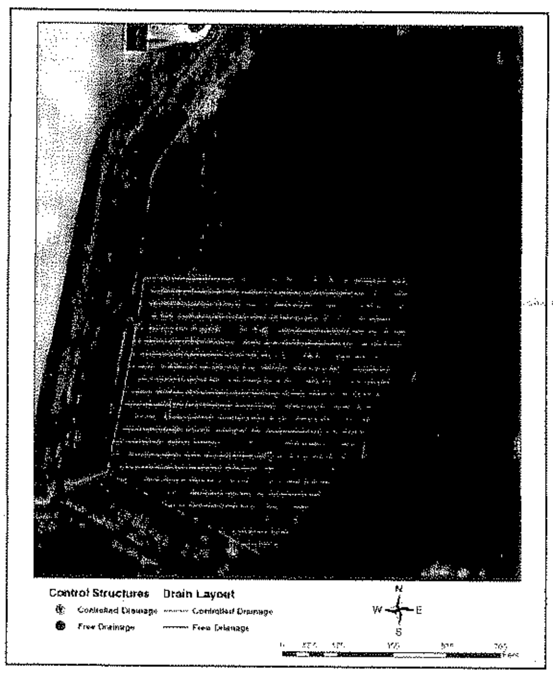


Figure 11. Dunkirk site topographical map.

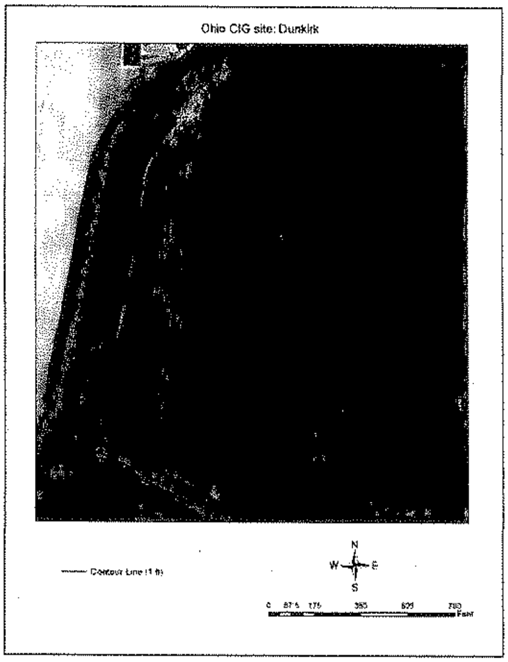


Figure 12. Dunkirk site aerial map.

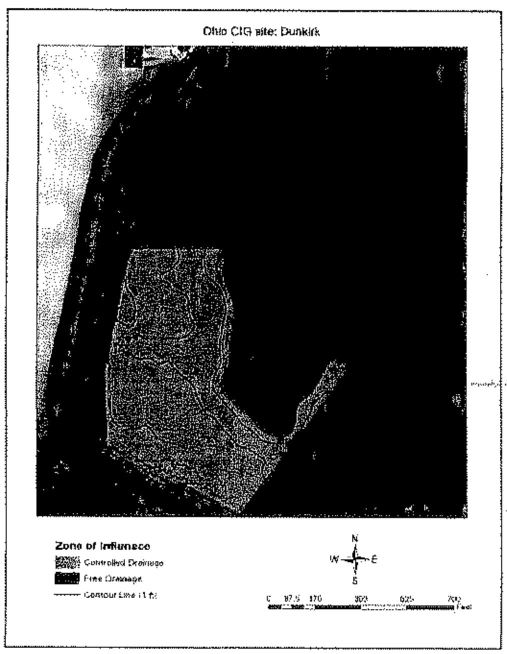


Figure 13. Lakeview site soil map.

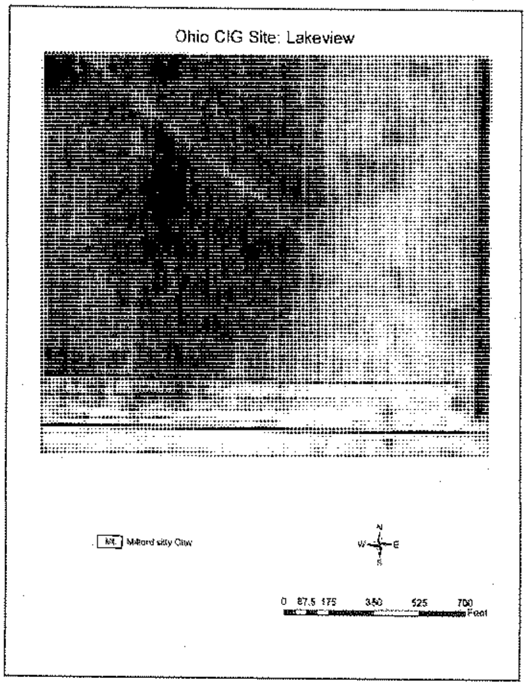


Figure 14. Lakeview site tile map.

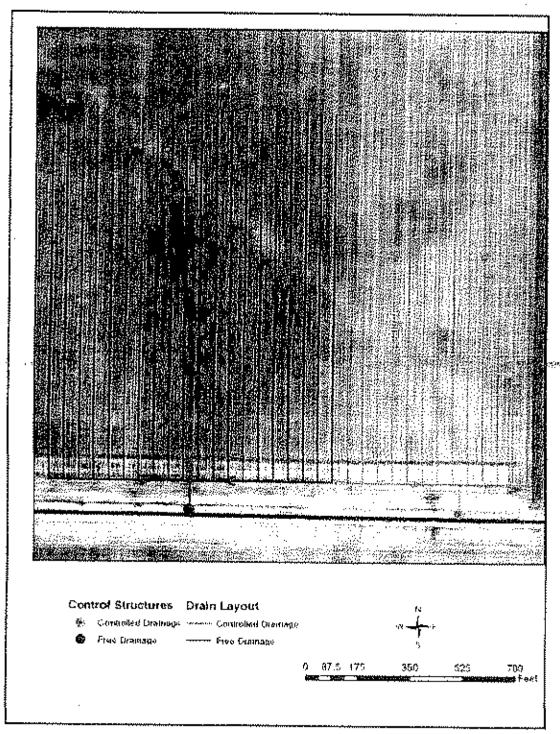


Figure 15. Lakeview site topographical map.

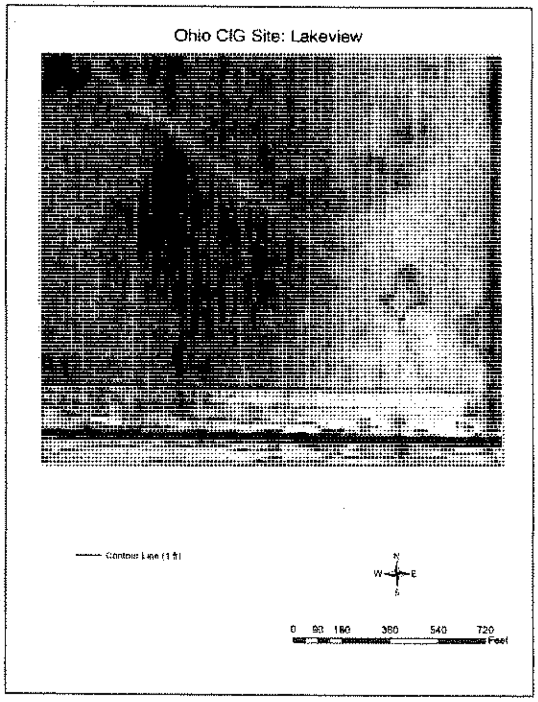
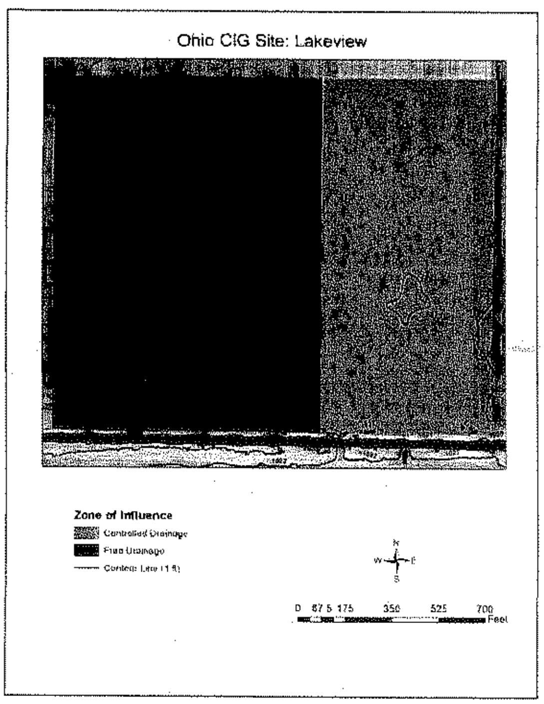


Figure 16. Lakeview site aerial map.



Water Management Plan

Figure 17. <u>Recommended</u> Control Plan for DWM at Different Ohio Sites.

site	Defiance From bottom of WTCs, Depth = 41"=7"+7"+5"+7"+5"+7"+Vboard (Vboard = 3"); Depth = 37"=5"+5"+7"+5"+7"+5"+Vboard											
week	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
1	41"	41"	41"	3"	3"	3"	37"	37"	37"	3"	3"	37"
2	41"	41"	41"	3"	3"	3"	37"	37"	37"	3"	3"	37"
3	41"	41"	41"	3"	3"	3"	37"	37"	37"	3"	3"	37"
4	41"	41"	41"	3"	3"	3"	37"	37"	37"	3"	3"	37"
site	Dunkirk, Napolean, Lakeview From bottom of WTCs, Depth = 37"=5"+7"+5"+7"+5"+Vboard (V-board = 8"); Depth = 13"=5"+Vboard											
week	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
1	37"	37"	37"	13"	13"	13"	37"	37"	37"	13"	13"	37"
2	37"	37"	37"	13"	13"	13"	37"	37"	37"	13"	13"	37"
3	37"	37"	37"	13"	13"	13"	37"	37"	37"	13"	13"	37"
4	37"	37"	37"	13"	13"	13"	37"	37"	37"	13"	13"	37"

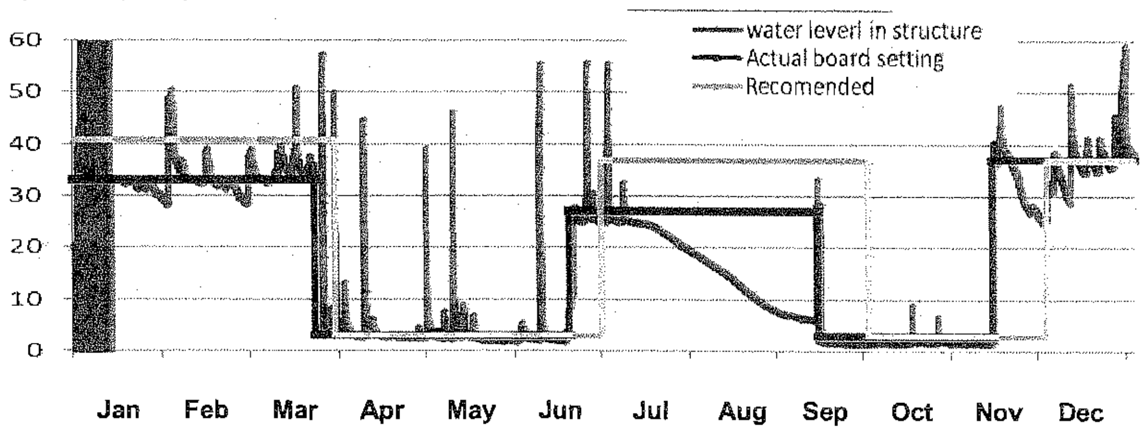
Comments: At Defiance, the top board is a 7" V-notch board, with a 4" V-notch cut, depth of the top board is 3" to the v-point. At Dunkirk, Napolean,and Lakevew, the top board is a 12" V-notch board, with a 4" V-notch cut, depth of the top board is 8" to the v-point. In the following graphs, data were plotted only when water levels were available from <u>both</u> structures at a site.

Figure 18a. Actual Control Plan and Water Table for DWM in 2008 (depth from bottom of structure in inches) – Defiance

Note: Top board is a 7" V-notch board, with a 4" V-notch cut, depth of the top board is 3" to the v-point.

Actual setting	Soybeans (2008) 34"= 7"+5"+7"+5"+7"+Vboard 3"=Vboard 37"=5"+5"+7"+5"+7"+5"+Vboard 27"=7"+5"+7"+5"+Vboard											
Week	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	34"	34"	34"	3"	3"	3"	27"	27"	27"	3"	3"	37"
2	34"	34"	34"	3"	3"	3"	27"	27"	27"	3"	3"	37"
3	34"	34"	34"	3"	3"	3"	27"	27"	3"	3"	37"	37"
4	34"	34"	3"	3"	3"	27"	27"	27"	3"	3"	37"	37"

Soybeans (2008) - Defiance



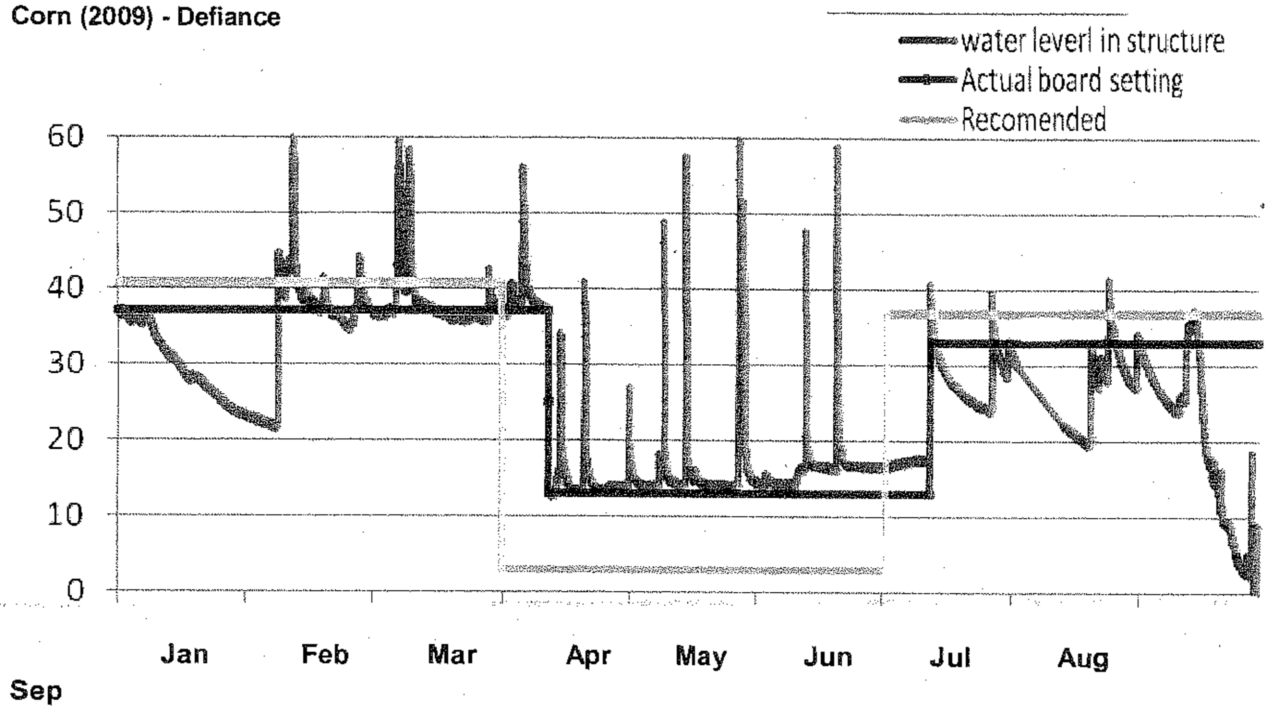
Comments: The water depth at the beginning of January, up to Jan 16th in 2008 was not considered reasonable, possibly because of instrument failure. Also, some single discrete readings (negative or readings more than 60 inches) were deleted.

Figure 18b. Actual Control Plan and Water Table for DWM in 2009 (depth from bottom of structure in inches) – Defiance.

Note: Top board is a 7" V-notch board, with a 4" V-notch cut, depth of the top board is 3" to the v-point.

Actual setting	Corn (2009)					37"=5"+5"+7"+5"+7"+5"+Vboard			13"=5"+5"+Vboard			
Week	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	37"	37"	37"	37"	13"	13"	13"	13"	13"	13"	13"	13"
2	37"	37"	37"	13"	13"	13"	13"	13"	13"	13"	13"	13"
3	37"	37"	37"	13"	13"	13"	13"	13"	13"	13"	13"	13"
4	37"	37"	37"	13"	13"	13"	13"	13"	13"	13"	13"	13"

Corn (2009) - Defiance



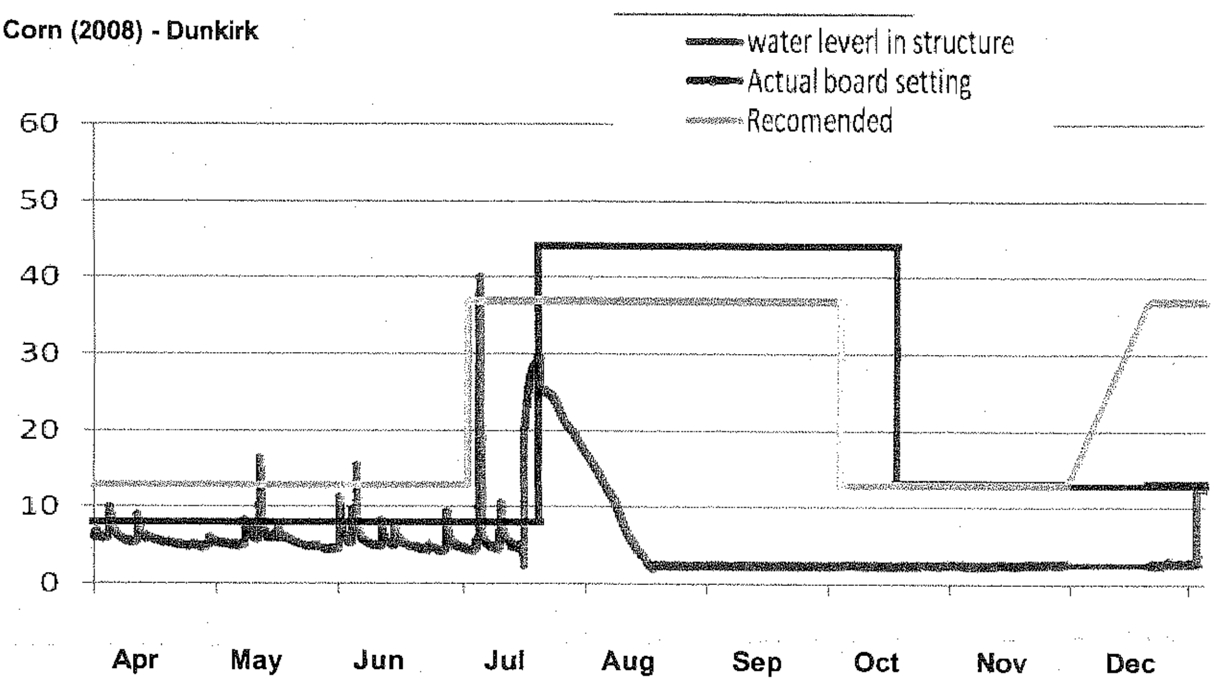
Comments: The readings of water table after September were not used due to instrument failure.

Figure 19a. Actual Control Plan and Water Table for DWM in 2008 (depth from bottom of structure in inches) – Dunkirk.

Note: Top board is a 12" V-notch board, with a 4" V-notch cut, depth of the top board is 8" to the v-point.

Actual Setting	Corn (2008)											
Week	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1	36"	36"	36"	8"	8"	8"	8"	44"	44"	44"	13"	13"
2	36"	36"	36"	8"	8"	8"	8"	44"	44"	44"	13"	13"
3	36"	36"	8"	8"	8"	8"	44"	44"	44"	13"	13"	13"
4	36"	36"	8"	8"	8"	8"	44"	44"	44"	13"	13"	13"

Corn (2008) - Dunkirk



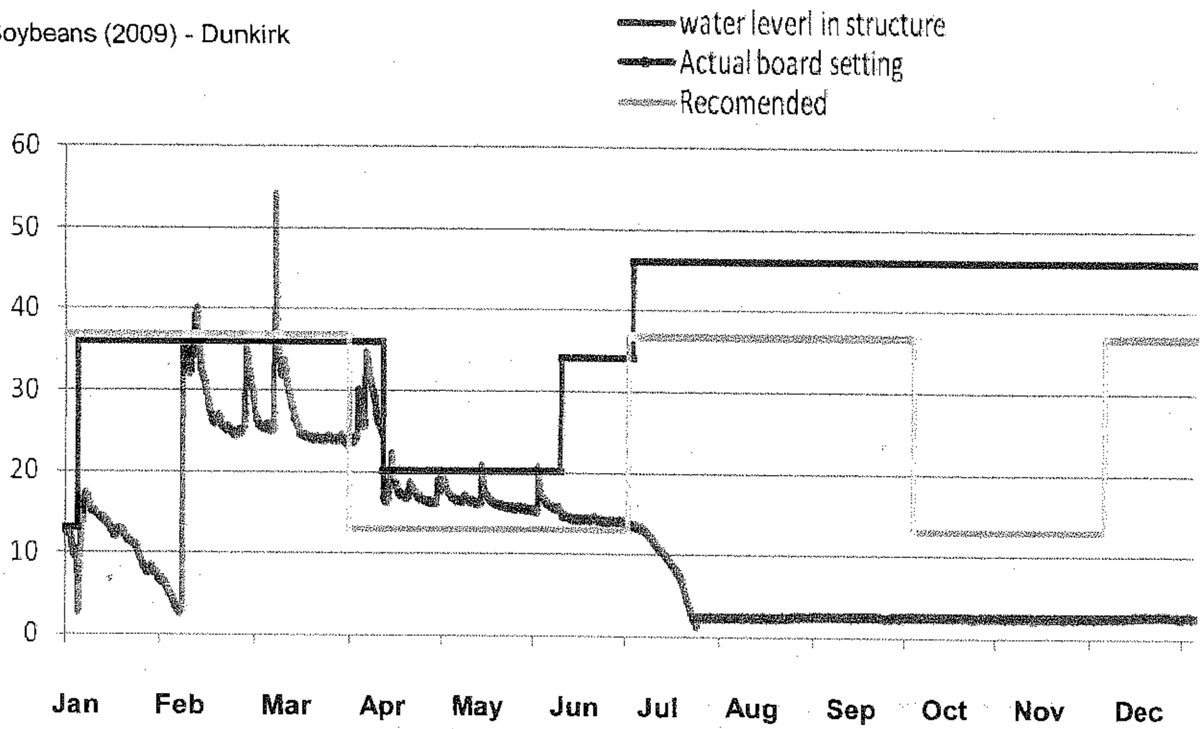
Comments: Water level before April 2008 was not available. Also, the water level from Dec 1st to Dec 26th was lost due to instrument failure. And the recommended time of lifting the board is at the beginning of December.

Figure 19b. Actual Control Plan and Water Table for DWM in 2009 (depth from bottom of structure in inches) – Dunkirk.

Note: Top board is a 12" V board, with a depth of 4" V cut and the depth of the top board is 8" to the v-point.

Actual Setting	Soybeans (2009)											
Week	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1	36"	36"	36"	36"	20"	20"	46"	46"	46"	46"	46"	46"
2	36"	36"	36"	36"	20"	34"	46"	46"	46"	46"	46"	46"
3	36"	36"	36"	20"	20"	34"	46"	46"	46"	46"	46"	46"
4	36"	36"	36"	20"	20"	34"	46"	46"	46"	46"	46"	46"

Soybeans (2009) - Dunkirk



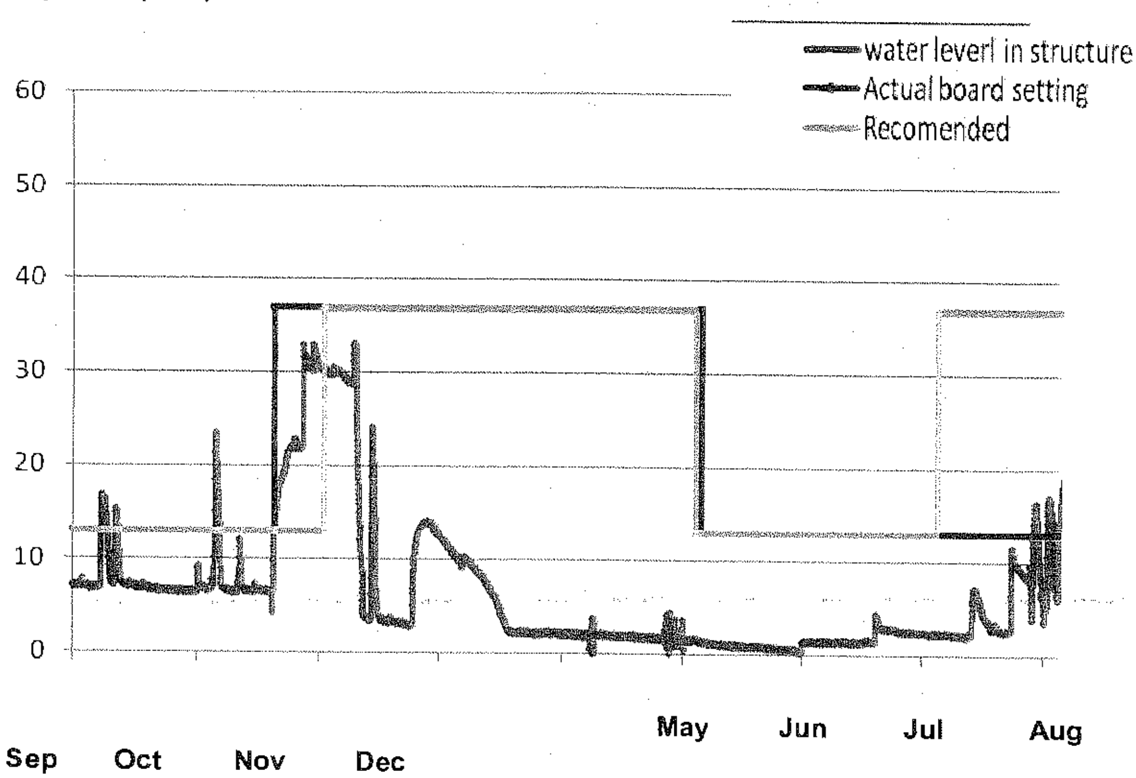
Comments:

Figure 20a. Actual Control Plan and Water Table for DWM in 2008 (depth from bottom of structure in inches) – Lakeview.

Note: top board is a 12" V board, with a depth of 4" V cut and the depth of the top board is 8" to the v-point.

Actua Setting	Soybeans (2008)											
Week	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1	39"	39"	39"	13"	13"	13"	37"	37"	37"	13"	13"	13"
2	39"	39"	39"	13"	13"	13"	37"	37"	37"	13"	13"	13"
3	39"	39"	39"	13"	13"	37"	37"	37"	37"	13"	13"	13"
4	39"	39"	13"	13"	13"	37"	37"	37"	37"	13"	13"	13"

Soybeans (2008) - Lakeview



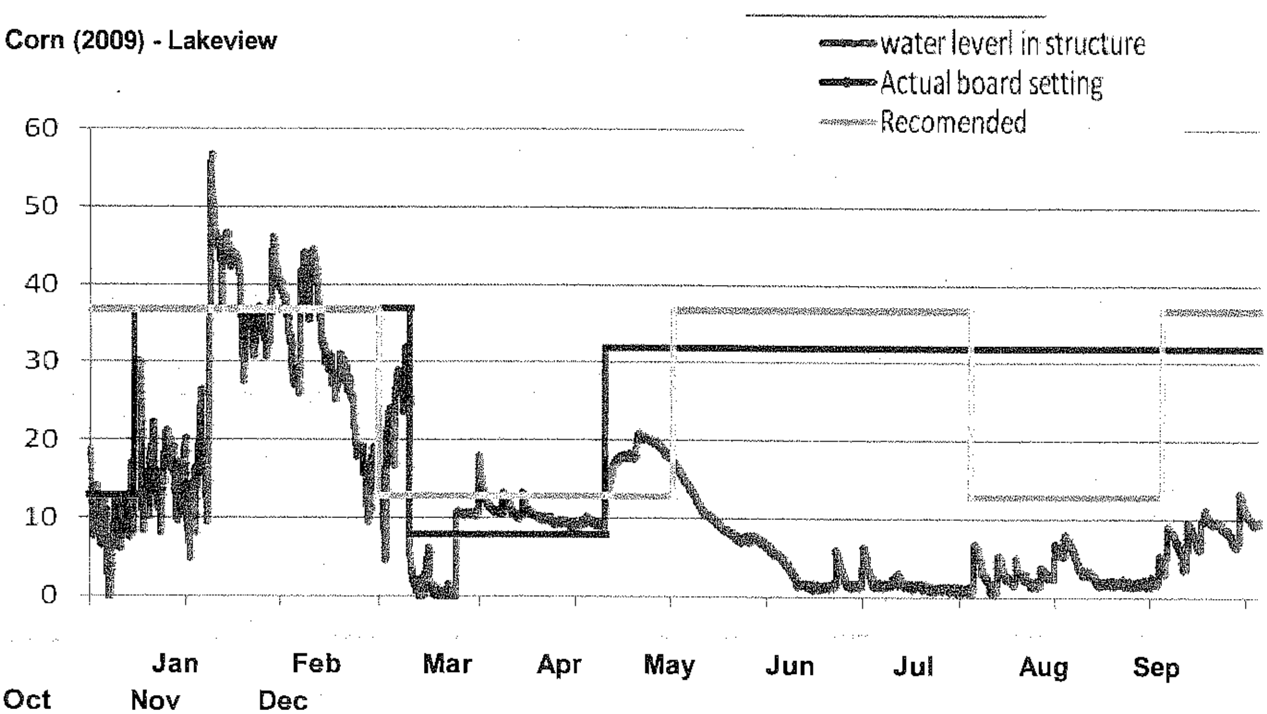
Comments:

Figure 20b. Actual Control Plan and Water Table for DWM in 2009 (depth from bottom of structure in inches) – Lakeview.

Note: top board is a 12" V board, with a depth of 4" V cut and the depth of the top board is 8" to the v-point.

Actua Settin g	Corn (2009)											
Week	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1	13"	37"	37"	37"	8"	8"	32"	32"	32"	32"	32"	32"
2	13"	37"	37"	8"	8"	32"	32"	32"	32"	32"	32"	32"
3	37"	37"	37"	8"	8"	32"	32"	32"	32"	32"	32"	32"
4	37"	37"	37"	8"	8"	32"	32"	32"	32"	32"	32"	32"

Corn (2009) - Lakeview



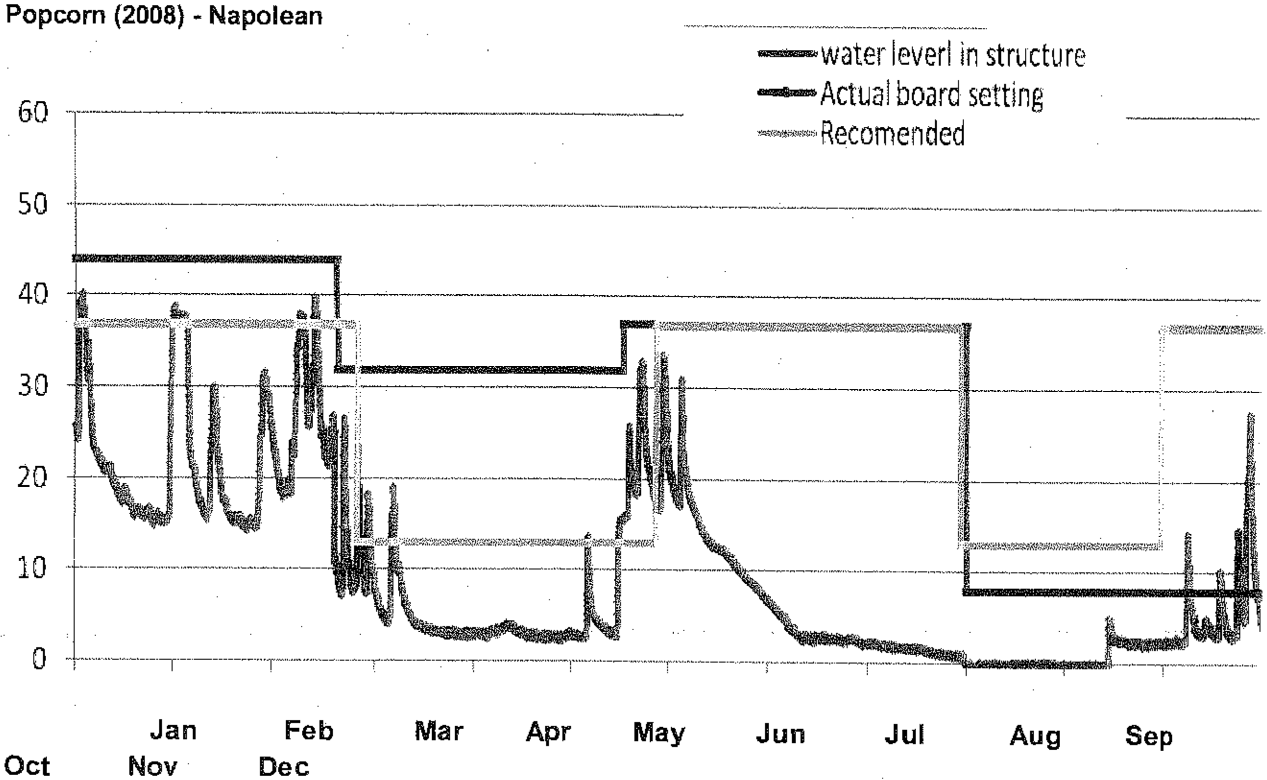
Comments: The actual board setting after August might be wrong due to the loss of some field records.

Figure 21a. Actual Control Plan and Water Table for DWM in 2008 (depth from bottom of structure in inches) – Napolean.

Note: top board is a 12" V board, with a depth of 4" V cut and the depth of the top board is 8" to the v-point.

Actual Setting	Popcorn (2008)											
Week	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1	44"	44"	44"	32"	32"	32"	37"	37"	37"	8"	8"	8"
2	44"	44"	44"	32"	32"	32"	37"	37"	37"	8"	8"	8"
3	44"	44"	44"	32"	32"	32"	37"	37"	37"	8"	8"	8"
4	44"	44"	32"	32"	32"	37"	37"	37"	37"	8"	8"	8"

Popcorn (2008) - Napolean

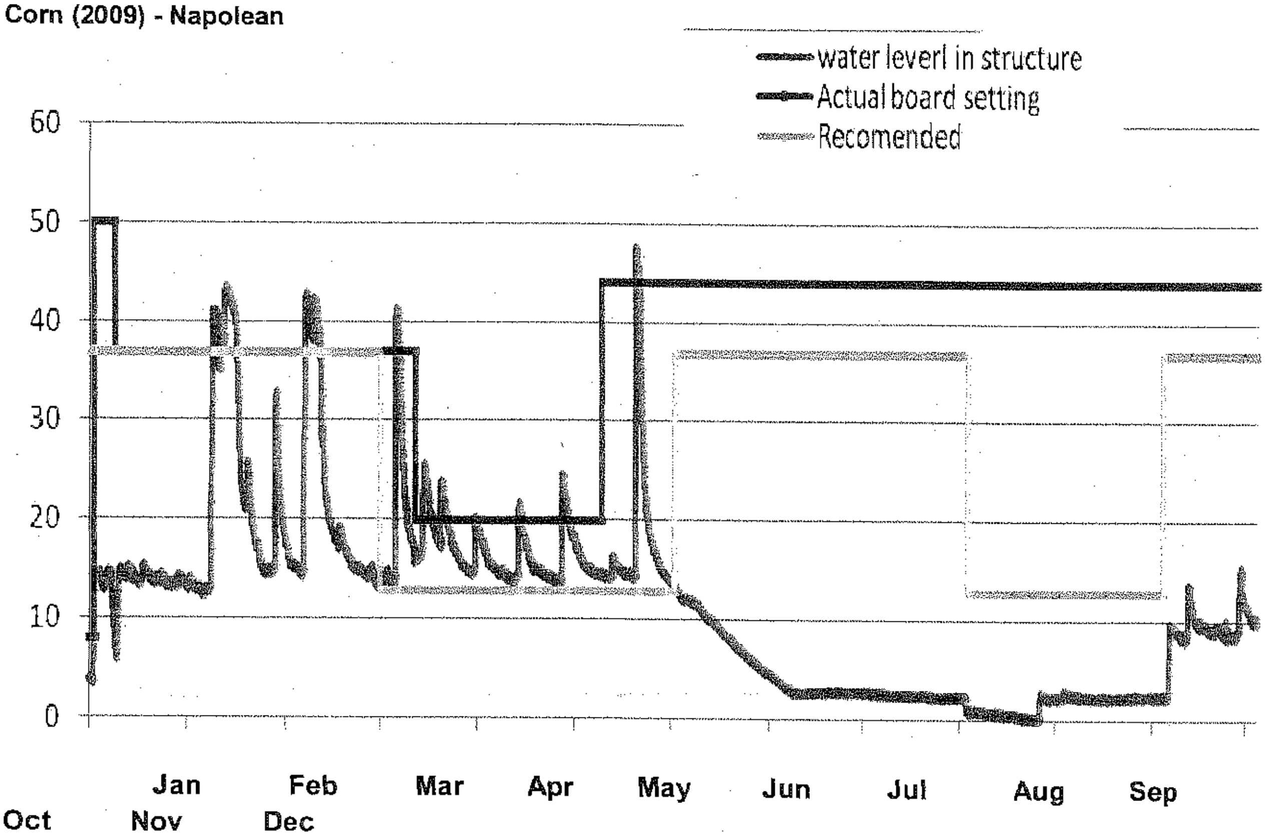


Comments:

Figure 21b. Actual Control Plan and Water Table for DWM in 2009 (depth from bottom of structure in inches) – Napolean.
Note: top board is a 12" V board, with a depth of 4" V cut and the depth of the top board is 8" to the v-point.

Actual Setting	Corn (2009)											
Week	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1	50"	37"	37"	37"	20"	20"	44"	44"	44"	44"	44"	44"
2	37"	37"	37"	20"	20"	44"	44"	44"	44"	44"	44"	44"
3	37"	37"	37"	20"	20"	44"	44"	44"	44"	44"	44"	44"
4	37"	37"	37"	20"	20"	44"	44"	44"	44"	44"	44"	44"

Corn (2009) - Napolean



Comments: The actual board setting at the beginning of January may be wrong due to incomplete field records.

Cropping and yield data

Cropping and yield data for Defiance, Ohio, CIG site.

		2006		2007		2008		2009	
Crop		Soybean		Corn		Soybean		Corn	
Variety		Pioneer 93B82		P34A16		Pioneer 93B82		Pioneer 33D14	
Planting Date		4/22/06		5/28/07		5/24/08		5/20/09	
Row Spacing		15"		30"		15"		30"	
Tillage	**Conventional**	na		na		na		na	
	Conservation	na		na		na		na	
	No Till	No Till		No Till		No-Till		No Till	
Nitrogen		none				none			
Fall N application	**Date**	none		1/19/07		none		na	
	Actual N#s/acre	none		25		none		100# 0-0-60; 110# 18-46-0	
Pre-plant N application	**Date**	none		5/9/07		none		na	
	Actual N#s/acre	none		42		none		15gal 28%	
Post-plant N application	**Date**	none		6/1/07		none		6/23/09	
	Actual N#s/acre	none		135		none		50gal 28%	
Phosphorus	**Actual P#s/acre**	none		56 lbs		none		See above	
Potash	**Actual K#s/acre**	none		86 lbs		none		See above	
Herbicide	**oz/acre**	CANOPY/BOUNDRY 3oz/2.4pts		BICAP II/Balance Pro/240		Pre 24oz Roundup; 1/2pt 2, 4-D; 12oz		2.6qt Bicrep II Magnium 1.8oz Balance	
Insecticide	**oz/acre**	none		Aztec 2vl 6.7 lbs/acre		none		none	
Harvest date		10/13/06		10/29/07		10/10/08		11/12/09	
	MD-managed drainage, CD-conventional drainage	na	CD	MD	CD	MD	CD	MD	CD
Yield		na	47	na	149	28	28	124	139
Moisture		na	13	na	15	12	12	28-30	28-30
Comments (hail, drought, heat, wind, etc.)									

Cropping and yield data for Ohio CIG Napolean site, 2006-2009.

		2006		2007		2008		2009	
Crop		Popcorn		Soybean		Popcorn		Corn	
Variety		VYP 313		Asgrow 3121		Test Plot		Dekalb 6169 Crows 4688 Dekalb 6122	
Planting Date		5/7/2006		5/15/07		5/20/08		5/19/09	
Row Spacing		30"		7.5"		30"		30"	
Tillage	**Conventional**	Conventional		No Till		No-Till		na	
	Conservation	na		na		na		1 pass Krouse Lands	
	No Till	na		na		na		na	
Nitrogen				na					
Fall N application	**Date**	None		na		None		None	
	Actual N#s/acre	None		na		na		na	
Pre-plant N application	**Date**	na		na		5/20/08		5/19/09	
	Actual N#s/acre	30		na		30 at plant		35 28%	
Post-plant N application	**Date**	na		na		na		6/10/09	
	Actual N#s/acre	90		na		140		205	
Phosphorus	**Actual P#s/acre**	189		na		32 at plant		5	
Potash	**Actual K#s/acre**	None		150		90 preplant		150	
Herbicide	**oz/acre**	Fulltime/Princep/Callis to 2.5qt/ac, 1.1#/ac, 3oz/ac		Canopy/Buccaneer Plus 3oz/ac, 1qt/ac		Simtrol 4L 1qt/ac; Degree Xtra 2.5qt/ac; Bucaneer Plus 26oz/ac; Weedone LV41pt/ac		Keystone 2qt/ac Atrazine 1qt/ac Glyphosate 1qt/a	
Insecticide	**oz/acre**	Capture 5.12oz/ac		none		Aztec 4.67G 3.27#/ac Warrior 3.27#/ac		none	
Harvest date		10/27/06		10/6/07, 10/7/07		10/23/08		12/1/09	
	MD-managed drainage, CD-conventional drainage	na	CD	MD	CD	MD	CD	MD	CD
Yield		na	na	59	55	58	59	214	201
Moisture		na	na	13	12	16	16	22	22
Comments (hail, drought, heat, wind, etc.)		No comparison		No true comparison					

Cropping and yield data for Dunkirk, Ohio, CIG site 2008-2009.

		2008		2009	
Crop		Corn		Soybean	
Variety		Starx		Wcllmar 3827r	
Planting Date		5/29/08		5/18/09	
Row Spacing		30"		15"	
Tillage	**Conventional**	Conventional		x	
	Conservation	x		x	
	No Till	x		No-Till	
Nitrogen				none	
Fall N application	**Date**	none		na	
	Actual N#s/acre	none		na	
Pre-plant N application	**Date**	none		na	
	Actual N#s/acre	35 (at plant)		na	
Post-plant N application	**Date**			na	
	Actual N#s/acre	145		na	
Phosphorus	**Actual P#s/acre**	60		na	
Potash	**Actual K#s/acre**	120		120	
Herbicide	**oz/acre**	Harx? 3pt; Roundup 22oz		RR 22oz	
Insecticide	**oz/acre**	na		na	
Harvest date		10/22/08		10/13/09	
	MD-managed drainage, CD-conventional drainage	MD	CD	MD	CD
Yield		123	107	57	55
Moisture		19	19	na	na
Comments (hail, drought, heat, wind, etc.)					

Cropping and yield data for Ohio CIG Napolean site, 2006-2009.

		2006		2007		2008		2009	
Crop		Popcorn		Soybean		Popcorn		Corn	
Variety		VYP 313		Asgrow 3121		Test Plot		Dekalb 6169 Crows 4688 Dekalb 6122	
Planting Date		5/7/2006		5/15/07		5/20/08		5/19/09	
Row Spacing		30"		7.5"		30"		30"	
Tillage	Conventional	Conventional		No Till		No-Till		na	
	Conservation	na		na		na		1 pass Krouse Lands	
	No Till	na		na		na		na	
Nitrogen				na					
Fall N application	Date	None		na		None		None	
	Actual N#s/acre	None		na		na		na	
Pre-plant N application	Date	na		na		5/20/08		5/19/09	
	Actual N#s/acre	30		na		30 at plant		35 28%	
Post-plant N application	Date	na		na		na		6/10/09	
	Actual N#s/acre	90		na		140		205	
Phosphorus	Actual P#s/acre	189		na		32 at plant		5	
Potash	Actual K#s/acre	None		150		90 preplant		150	
Herbicide	oz/acre	Fulltime/Princep/Callis to 2.5qt/ac, 1.1#/ac, 3oz/ac		Canopy/Buccaneer Plus 3oz/ac, 1qt/ac		Simtrol 4L 1qt/ac; Degree Xtra 2.5qt/ac; Bucaneer Plus 26oz/ac; Weedone LV41pt/ac		Keystone 2qt/ac Atrazine 1qt/ac Glyphosate 1qt/a	
Insecticide	oz/acre	Capture 5.12oz/ac		none		Aztec 4.67G 3.27#/ac Warrior 3.27#/ac		none	
Harvest date		10/27/06		10/6/07, 10/7/07		10/23/08		12/1/09	
	MD-managed drainage, CD-conventional drainage	na	CD	MD	CD	MD	CD	MD	CD
Yield		na	na	59	55	58	59	214	201
Moisture		na	na	13	12	16	16	22	22
Comments (hail, drought, heat, wind, etc.)		No comparison		No true comparison					

Table 1. Long-term monthly means, and 2008-2009 monthly precipitation for the Ohio CIG site at Defiance.

Month	Precipitation (in) 28-yr ave	2008		2009	
		Precipitation (in)	Departure (in)	Precipitation (in)	Departure (in)
Jan	1.97	2.86	0.89	0.4	-1.57
Feb	1.84	4.61	2.77	2.96	1.12
Mar	2.63	3.64	1.01	5.24	2.61
Apr	3.3	2.82	-0.48	4.96	1.66
May	3.61	3.3	-0.31	5.7	2.09
Jun	3.88	5.64	1.76	3.76	-0.12
Jul	3.63	2.92	-0.71	3.37	-0.26
Aug	3.49	0.84	-2.65	3.54	0.05
Sep	2.91	4.69	1.78	1.4	-1.51
Oct	2.44	2.03	-0.41	5.14	2.7
Nov	2.89	2.38	-0.51	1.18	-1.71
Dec	2.59	3.62	1.03	2.59	0
Annual	35.18	39.35	4.17	40.24	5.06

Table 2. Long-term monthly means, and 2008-2009 monthly precipitation for the Ohio CIG site at Dunkirk.

Month	Precipitation (in) 33-yr ave	2008		2009	
		Precipitation (in)	Departure (in)	Precipitation (in)	Departure (in)
Jan	1.97			0.28	-1.69
Feb	1.84			3.35	1.51
Mar	2.63			3.49	0.86
Apr	3.3	3.1	-0.2	4.56	1.26
May	3.61	2.76	-0.85	1.32	-2.29
Jun	3.88	4.05	0.17	1.62	-2.26
Jul	3.63	0.41	-3.22	1.3	-2.33
Aug	3.49	0.33	-3.16	1.1	-2.39
Sep	2.91	0.47	-2.44	0.7	
Oct	2.44	0.89	-1.55	1.32	
Nov	2.89			6.45	
Dec	2.59				
Annual	35.18			25.49	

Data missing for these periods: 1/16-3/8; 11/27-11/30; 12/1-12/15.

Data considered problematic shown in red.

Table 3. 2008-2009 monthly precipitation for the Ohio CIG Site at Napoleon.

Month	Precipitation (in)	
	2008	2009
Jan	1.69	0.13
Feb	5.37	3.95
Mar	3.31	4.53
Apr	3.56	4.73
May	2.79	1.35
Jun	6.17	2.55
Jul	3.39	2.04
Aug	0.16	3.16
Sep	4.22	1.27
Oct	1.89	3.9
Nov	3.31	0.33
Dec	3.43	1.97
Annual	39.29	29.91

Historical data not readily available; will add once located from Henry County.

Table 4. Long-term monthly means, and 2008-2009 monthly precipitation for the Ohio CIG site at Lakeview.

Month	Precipitation (in) 51-yr ave	2008		2009	
		Precipitation (in)	Deviation (in)	Precipitation (in)	Deviation (in)
Jan	2.5	3.48	0.98	0.09	-0.89
Feb	2.15	5.43	3.28	2.54	-0.74
Mar	2.8	6.67	3.87	2.08	-1.79
Apr	3.48	2.79	-0.69	7.1	7.79
May	4.16	6	1.84	2.46	0.62
Jun	4.16	6.9	2.74	2.3	-0.44
Jul	4.23	3.94	-0.29	2.46	2.75
Aug	3.76	0.78	-2.98	2.77	5.75
Sep	2.88	2.14	-0.74	1.74	2.48
Oct	2.56	1.46	-1.1	1.57	2.67
Nov	3.14	2.31	-0.83	1.18	2.01
Dec	2.86	4.11	1.25	2.57	1.32
Annual	38.68	46.01	7.33	28.86	21.53

Table 1. Preliminary nutrient load reduction data for Ohio Regional Project CIG Sites for May-August, 2009, based on preliminary flow data presented earlier, and limited number of samples.

2009 Preliminary Nutrient Load (#/ac) Reduction: Ohio CIG site at Defiance

Month	NO3-N			PO4-P		
	FD	MD	Reduction (%)	FD	MD	Reduction (%)
Mar	6.2	1.4	77.8	0.196	0.787	-300.9
Apr	7.9	4.6	41.0	0.231	3.1	-1240.3
May	5.3	6.0	-13.6	0.257	4.3	-1551.0
Jun	2.5	6.8	-174.6	0.091	8.1	-8804.7
Jul	0.0	1.7	-4316.7	0.005	1.1	-22666.5
Aug				0.005	0.0	100.0
Annual	21.8	20.4	6.3	0.8	17.4	-2115.1

2009 Preliminary Nutrient Load (#/ac) Reduction: Ohio CIG site at Napolean

Month	NO3-N			PO4-P		
	FD	MD	Reduction (%)	FD	MD	Reduction (%)
Mar	8.8	0.3	96.5	0.314	0.007	97.7
Apr	13.7	0.3	97.7	0.327	0.007	97.9
May	4.2	0.0	99.0	0.199	0.002	99.1
Jun	4.5	0.0	99.4	0.07	0.001	98.4
Jul	0.0	0.0	0.0	0.0	0.0	0.0
Aug	0.0	0.0	0.0	0.0	0.0	0.0
Annual	31.1	0.7	392.5	0.911	0.017	98.1

2009 Preliminary Nutrient Load (#/ac) Reduction: Ohio CIG site at Dunkirk

Month	NO3-N			PO4-P		
	FD	MD	Reduction (%)	FD	MD	Reduction (%)
Mar	1.6	0.5	66.7	0.028	0.007	75.0
Apr	2.7	0.0	99.9	0.112	0.0	99.9
May	1.0	0.0	100.0	0.025	0.0	100.0
Jun	0.3	0.0	100.0	0.015	0.0	100.0
Jul	1.6	0.0	100.0	0.058	0.0	100.0
Aug	0.0	0.0	0.0	0.0	0.0	0.0
Annual	7.1	0.5	92.6	0.238	0.007	97.0

2009 Preliminary Nutrient Load (#/ac) Reduction: Ohio CIG site at Lakeview

Month	NO3-N			PO4-P		
	FD	MD	Reduction (%)	FD	MD	Reduction (%)
Mar	0.8	0.8	-4.7	0.011	0.01	13.1
Apr	2.0	2.2	-11.4	0.023	0.021	10.1
May	3.6	1.6	56.4	0.033	0.023	31.0
Jun	0.1	0.3	-400.4	0.001	0.005	-497.3
Jul	0.1	0.2	-252.3	0.003	0.007	-152.9
Aug	0.01	0.05	-317.5	0.002	0.004	-92.0
Annual	6.5	5.2	20.3	0.073	0.069	5.4

Table 1: Drainage outflow totals, monthly and annual, for 2008-2009 for Ohio CIG site at Defiance.

	Month	P (in)	FD (20 ac)		MD (19 ac)		Reduction		Ratio
			(gal)	(in/ac)	(gal)	(in/ac)	(gal)	(in/ac)	
2008	Jan	2.86	482705	0.9	0	0.0	482705	0.9	100
	Feb	4.61	3448481	6.7	1442224	2.7	2006257	4.0	60
	Mar	3.64	6051249	11.7	2167397	4.0	3883852	7.7	66
	Apr	2.82	2253254	4.4	914166	1.7	1339088	2.7	61
	May	3.3	1188561	2.3	513913	0.9	674647	1.4	59
	Jun	5.64	931295	1.8	767109	1.4	164186	0.4	22
	Jul	2.92	624527	1.2	341509	0.6	283018	0.6	48
	Aug	0.84	0	0.0	0	0.0	0	0.0	0
	Sep	4.69	86911	0.2	60300	0.1	26611	0.1	34
	Oct	2.03	28317	0.1	32846	0.1	**-4529**	0.0	-10
	Nov	2.38	719826	1.4	492260	0.9	227566	0.5	35
	Dec	3.62	2685577	5.2	1673118	3.1	1012459	2.1	41
	Total	39.35	18500704	35.9	8404843	15.5	10095860	20	57
2009	Jan	0.4	266447	0.5	0	0.0	266447	0.5	100
	Feb	2.96	3237967	6.3	2134134	3.9	1103833	2.3	37
	Mar	5.24	2048252	4.0	1374796	2.5	673456	1.4	36
	Apr	4.96	2310241	4.5	1601313	2.9	708928	1.5	34
	May	5.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Jun	3.76	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Jul	3.37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Aug	3.54	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Sep	1.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Oct	5.14							
	Nov	1.18							
	Dec	2.59							
	Total	40.24							
Average Annual		39.80							

Notes:

1. These are preliminary data. Analysis continues.
2. Blue shaded area- In 2008, flow information available starting January 16th.
3. Pink shaded area - In 2009, flow information stopped on or about September 30th.
4. Gray sheded areas - From May to September 2009, water lavel readings at FD WTCs may be suspect; instrument failure on May 28th.
5. When flow at both FD and MD WTCs is zero, reduction rate not calculated.
6. Both WTCs discharge to same outlet pipe, which is slightly undersized, possibly resulting in backflow conditions that may have affected water levels readings in May through September 2009, and elsewhere.

Table 2: Drainage outflow totals, monthly and annual, for 2008-2009 for Ohio CIG site at Napolean.

	Month	P (in)	FD (35 ac)		MD (37ac)		Reduction		Ratio
			(gal)	(in/ac)	(gal)	(in/ac)	(gal)	(in/ac)	
2008	Jan	1.69							
	Feb	5.37							
	Mar	3.31							
	Apr	3.56							
	May	2.79	2192242	2.3	0	0.0	2192242	2.3	100
	Jun	6.17	6870969	7.2	0	0.0	6870969	7.2	100
	Jul	3.39	6133662	6.5	0	0.0	6133662	6.5	100
	Aug	0.16	438513	0.5	0	0.0	438513	0.5	100
	Sep	4.22	0	0.0	0	0.0	0	0.0	0
	Oct	1.89	0	0.0	0	0.0	0	0.0	0
	Nov	3.31	2969273	3.1	0	0.0	2969273	3.1	100
	Dec	3.43	7832312	8.2	1326004	1.3	6506308	6.9	84
	Total	39.29	26436971	27.8	1326004	1.3	25110967	26.5	95
2009	Jan	0.13	2073165	2.2	56867	0.1	2016298	2.1	97
	Feb	3.95	6937682	7.3	362393	0.4	6575290	6.9	95
	Mar	4.53	4719550	5.0	201482	0.2	4518068	4.8	96
	Apr	4.73	6244603	6.6	170485	0.2	6074118	6.4	97
	May	1.35	3561132	3.7	36881	0.0	3524251	3.7	99
	Jun	2.55	2572551	2.7	32672	0.0	2539879	2.7	99
	Jul	2.04	0	0.0	0	0.0	0	0.0	0
	Aug	3.16	0	0.0	0	0.0	0	0.0	0
	Sep	1.27	0	0.0	0	0.0	0	0.0	0
	Oct	3.9	9855	0.0	0	0.0	9855	0.0	100
	Nov	0.33	0	0.0	0	0.0	0	0.0	0
	Dec	1.97	1813692	1.9	0	0.0	1813692	1.9	100
	Total	29.91	27932232	29.4	860781	0.9	27071451	28.5	97
Average Annual		34.6	27184601	28.6	1093393	1.1	26091209	27.5	96

Notes:

1. These are preliminary data. Analysis continues.
2. Pink shaded areas - FD water level data available starting May 16th, 2008.
3. This site experienced some leakage, possibly through a sand lense in the lower soil profile or deep seepage. For the most part, where the eduction rate was 90 to 100%, the MD WTCs board setting was high and water levels seldom exceeded the board setting. Refer to earlier figure with board setting comparison.
4. When flow at both FD and MD WTCs is 0, reduction rate not calculated.

Table 3: Drainage outflow totals, monthly and annual, for 2008-2009 for Ohio CIG site at Dunkirk.

	Month	P (in)	FD (16 ac) (gal)	FD (16 ac) (in/ac)	MD (20 ac) (gal)	MD (20 ac) (in/ac)	Reduction (gal)	Reduction (in/ac)	Ratio
008	Jan	0.93							
	Feb								
	Mar	0.81							
	Apr	3.1	234595	0.5	972	0.0	233624	0.5	100
	May	2.76	575612	1.3	104527	0.2	471085	1.1	85
	Jun	4.05	463973	1.1	104841	0.2	359132	0.9	82
	Jul	0.41	508147	1.2	2375925	4.4	**-1867778**	**-3.2**	**-274**
	Aug	0.33	0	0.0	0	0.0	0	0.0	
	Sep	0.47	0	0.0	0	0.0	0	0.0	
	Oct	0.89	0	0.0	0	0.0	0	0.0	
	Nov	1.56	0	0.0	0	0.0	0	0.0	
	Dec	0.64	458261	1.1	0	0.0	458261	1.1	100
	Total	**15.95**	2240589	5.2	2586264	4.8	-345675	0.4	8
2009	Jan	0.28	2196238	5.1	0	0.0	2196238	5.1	100
	Feb	3.35	1775622	4.1	29347	0.1	1746275	4.0	99
	Mar	3.49	780529	1.8	170999	0.3	609530	1.5	82
	Apr	4.56	858057	2.0	1298	0.0	856758	2.0	100
	May	1.32	329550	0.8	0	0.0	329550	0.8	100
	Jun	1.62	171324	0.4	0	0.0	171324	0.4	100
	Jul	1.3	508147	1.2	0	0.0	508147	1.2	100
	Aug	1.1	0	0.0	0	0.0	0	0.0	
	Sep	**0.7**	0	0.0	0	0.0	0	0.0	
	Oct	**1.32**	0	0.0	0	0.0	0	0.0	
	Nov	**6.45**	0	0.0	0	0.0	0	0.0	
	Dec	0	0	0.0	0	0.0	0	0.0	
	Total	25.49	6619466	15.2	201645	0.4		14.9	98
Annual Average		-	11100644	25.5	5374173	9.9	5726471	15.7	61

Notes:

1. These are preliminary data. Analysis continues.
2. Blue shaded areas- February 2008 rainfall data not collected. Rainfall from September to November, 2009 may be suspect.
3. Pink shaded areas- Flow data before April 2008 are suspect – possible sensor failure or submerged outlet conditions.
4. When flow at both FD and MD WTCs is zero, reduction rate is not calculated.
5. Gray shaded area – Large negative flow reduction in July 2008 most likely due to ambiguous board setting record.

Table 4: Drainage outflow totals, monthly and annual, for 2008-2009 for Ohio CIG site at Lakeview.

	Month	P (in)	FD (29 ac)		MD (19 ac)		Reduction		Ratio
			(gal)	(in/ac)	(gal)	(in/ac)	(gal)	(in/ac)	
2008	Jan	3.48							
	Feb	5.43							
	Mar	6.67							
	Apr	2.79							
	May	6.0	1915488	2.4	743642	1.4	1171846	1.0	41
	Jun	6.9	1639045	2.1	517426	1.0	1121619	1.1	52
	Jul	3.94	851400	1.1	296833	0.6	554566	0.5	47
	Aug	0.78	18976	0.0	35376	0.1	**-16400**	**0.0**	**-185**
	Sep	2.14	16768	0.0	27196	0.1	**-10428**	**0.0**	**-148**
	Oct	1.46	16752	0.0	14838	0.0	**1914**	**0.0**	**-35**
	Nov	2.31	13411	0.0	46475	0.1	**-33064**	**-0.1**	**-429**
	Dec	4.11	624630	0.8	254318	0.5	370311	0.3	38
	Total	46.01	5096470	6.5	1936105	3.8	3160364	2.7	42
2009	Jan	0.09	24828	0.0	57062	0.1	**-32234**	**-0.1**	**-251**
	Feb	2.54	2235349	2.8	616287	1.2	1619062	1.6	58
	Mar	2.08	363962	0.5	162891	0.3	201072	0.1	32
	Apr	7.1	817212	1.0	481438	0.9	335774	0.1	10
	May	2.46	713595	0.9	382182	0.7	331413	0.2	18
	Jun	2.3	22764	0.0	59390	0.1	**-36626**	**-0.1**	**-298**
	Jul	2.46	24856	0.0	57212	0.1	**-32356**	**-0.1**	**-251**
	Aug	2.77	24048	0.0	29778	0.1	**-5730**	**0.0**	**-89**
	Sep	1.74	19539	0.0	24394	0.0	**-4854**	**0.0**	**-91**
	Oct	1.57	16752	0.0	37615	0.1	**-20862**	**-0.1**	**-243**
	Nov	1.18	18241	0.0	30773	0.1	**-12532**	**0.0**	**-157**
	Dec	2.57	180779	0.2	149158	0.3	**31621**	**-0.1**	**-26**
	Total	28.86	4461926	5.7	2088179	4.0	2373748	1.6	29
Average Annual		37.44	4779198	6.1	2012142	3.9	2767056	2.2	36

Notes:

1. These are preliminary data, measured with ADMC flow meter. Pink shaded areas - meter data not available until May 2008.
2. Ratio calculated from reduction of depth (in/ac), which takes into consideration the area of each field.
3. Gray shaded areas - Large number of negative flow reduction suspect. Analysis continues.

Project 3

GRAND LAKE/WABASH
WATERSHED ALLIANCE

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August 21, 2008

Clarence Bunch, Michelle Lohstroh and Julia Zehner
USDA/NRCS
200 N. High St., Room 522
Columbus, OH 43215

Dear Mr. Bunch, Ms. Lohstroh and Ms. Julia Zehner,

The following is the final report for grant agreement No. 69-5E34-07-87.

This report includes deliverables as outlined in the grant agreement, work performed, conclusions and recommendations.

This project has been a learning experience for everyone involved. We have gone from knowing very little about geotextile tubes to explaining what they are and how they can be used to dewater manure.

Our final report includes an appendix with conclusions and recommendations from two partners in the project. The third partner in the project chose not to submit a report to us. They told us their full report will be published in *Geosynthetics*. Two of these three partners do not see the geotextile tubes as a cost effective process on the farm at this time. The third of these partners stands firm, concluding that the geotextile tubes are cost effective on the farm. All partners agree that the geotextile tube technology works for dewatering manure and that there is a need for a full scale test.

Thank you,

L B. Walker

Laura Walker
Watershed Coordinator
Enclosures

Contents

Deliverables of Grant Agreement No. 69-5e34-07-87

Demonstrate the economic use of geotextile tubes:

The main objective of the project was to demonstrate to livestock producers in the Grand Lake St. Marys and Wabash River watersheds that geotextile tubes can be effectively used to economically dewater liquid manure. At the conclusion of this project, it was determined the geotextile tubes, as expected, were effective at dewatering the manure at the swine and dairy facilites. More details on the process are in the "Detailed Report of Geotextile Tube Technology."

However, two of the three project partners show this manure handling technique to not be economically feasible for the traditional livestock facility in these watersheds at this time. Further explanation is found below and budget summary for this project can be found in Appendix G. The watershed coordinator/grant facilitator requested three partners submit independent conclusions and recommendations to be included in this final grant report. The three partners were: Tom Rampe, retired professional engineer and member of the Lake Improvement Association; Theresa Dirksen, technician and former watershed coordinator Mercer County Soil and Water Conservation District; and Brian Mastin, PhD WaterSolve LLC and polymer consultant for the project. Reports were received from Rampe and Dirksen. Mastin said he was mailing a summary, but it was not received at the deadline for this final report. Mastin said he will be publishing his full report titled "Management of Swine and Dairy Manure with Geotube Dewatering Containers" in Geosythetics. He stated the report will be published in February 2009. The submitted reports can be seen in their entirety in Appendices E and F respectively.

The Grand Lake St. Marys and Wabash River Watersheds in Ohio are populated with small livestock facilities. A majority of the producers run the facility and work another full time job. Changes in their daily operations are driven by economics. If a best management practice will show an economic benefit, they are willing to do the practice. If the practice costs more than they will gain, it is usually not considered. All parties in this project agreed the geotextile tube manure dewatering technology works and that there is a need for a full scale project.

Below is a short summary of the two submitted reports:

Dirksen ran an estimate of a 1,000-head grow-to-finish swine facility. Estimated cost to set up the manure management portion of the facility for geotextile tube dewatering would be $80,000, not including infrastructure. Approximately $50,000 would be spent on the tubes, chemicals, labor and maintenance of the innovative manure handling system. At the time of her report, the estimated fertilizer value of the dewatered product would be $20,000. Dirksen mentioned that earning carbon credits with the innovative manure handling may increase the cost benefit, but at this time it is unknown how much additional income carbon credits would provide. She also recognized that the dewatered product could be brokered, similar to poultry manure. In the dewatered form, it is easier and more economical to transport than liquid manure.

Dirksen reported "Geotextile tubes can provide additional storage during winter months when used in conjunction with another manure storage system. They would allow for additional storage when inclement weather precludes manure application to fields."

Rampe reported the approximate value of the dewatered manure from the swine facility is $2,600. He added it cost approximately $8,600 to produce the material and haul it to another location to be utilized on the field. He stated the major portion of the cost is the geotextile tubes, estimated at 70 percent of the total project cost. If the tubes could be reused, this cost would be reduced. He reported the second largest expense as the chemical cost, estimated at $900. The third largest cost is the transportation of the dewatered material. He concluded his report, "...further research in other aspects of the process to reduce costs and improve process effectiveness may be warranted."

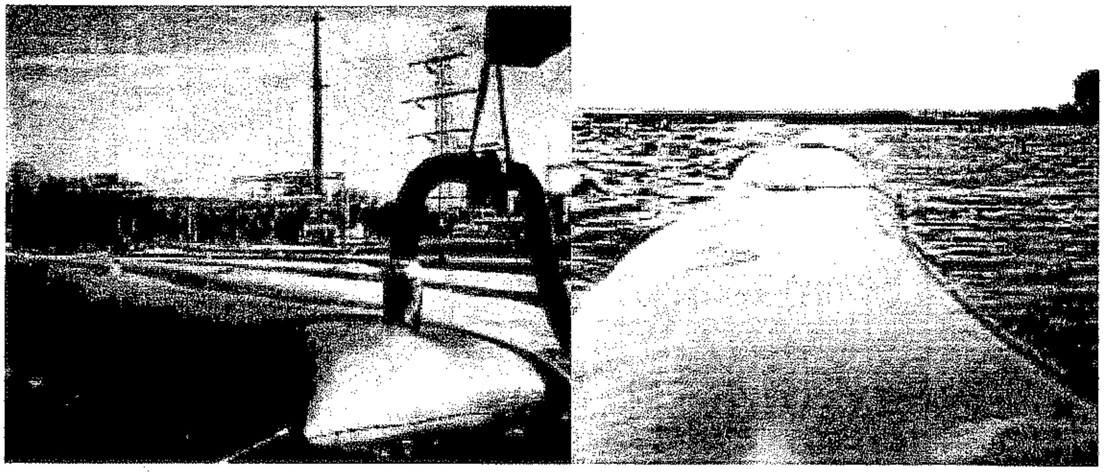
Detailed report of geotextile tube technology:

Geotextile tubes have been used for many years, starting in the paper making business. The tubes are often referred to as bags or Geotubes. Geotube® is a registered trademark of Tencate, a company who makes geotextile fabric and geotextile tubes.

Geotextile tubes are currently used for dewatering dredge materials. These materials range from organic material and sediment in ponds to toxic material from industrial sites. In these cases, a polymer must be added to capture all of the wanted materials. The polymer creates a chemical reaction, forcing the particles to clump together and force out the water. The tubes are also used for recreating beaches in the ocean. A polymer is not required for this type of site. The tubes are filled with sand, and then as the waves wash over the tubes, sand builds behind the tube, recreating the beach.

Seen below are several geotextile tube sites:

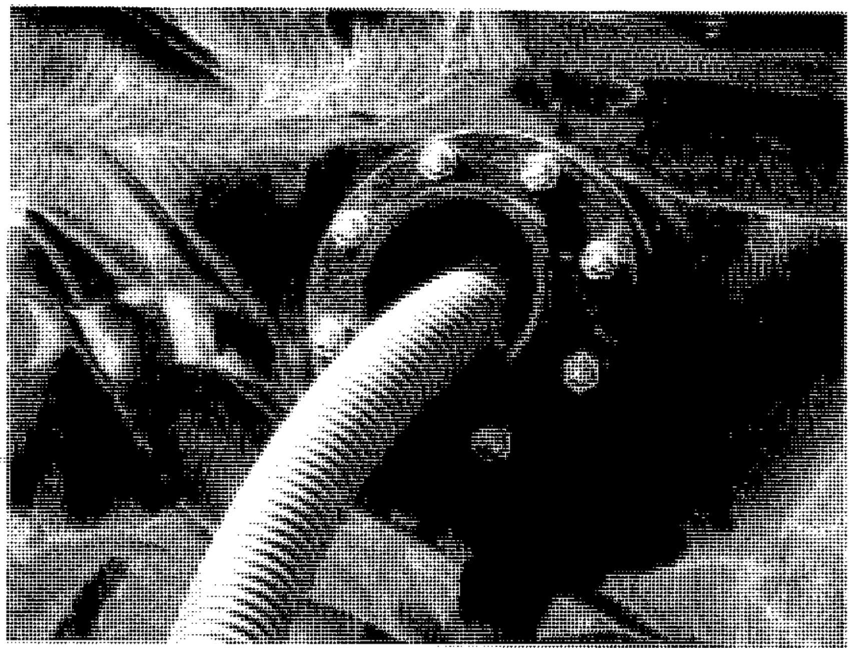
Lake dredge material dewatering site, Madison, Wisconsin.



Two Ellicott Dredges geotextile tube sites, on the left is an industrial site and on the right is an ocean site.

Geotextile tubes are similar to the geotextile landscaping fabric. The material allows water to pass in only one direction, out of the geotextile tube. Tubes used in this project were Geotubes® made by Tencate. Both the GT404 and GT500 were used. The GT404 is considered to be the "Ag bag." The GT404 costs less and has been used at other geotextile tube sites. The GT500 is used for many different types of sites. Function does not change with the bag type and no significant results were shown in this project. To see a comparison graph of the geotextile tubes turn to Appendix D. These graphs show the height of the bag, measured in inches, as it is filled and as it dewatered throughout the project.

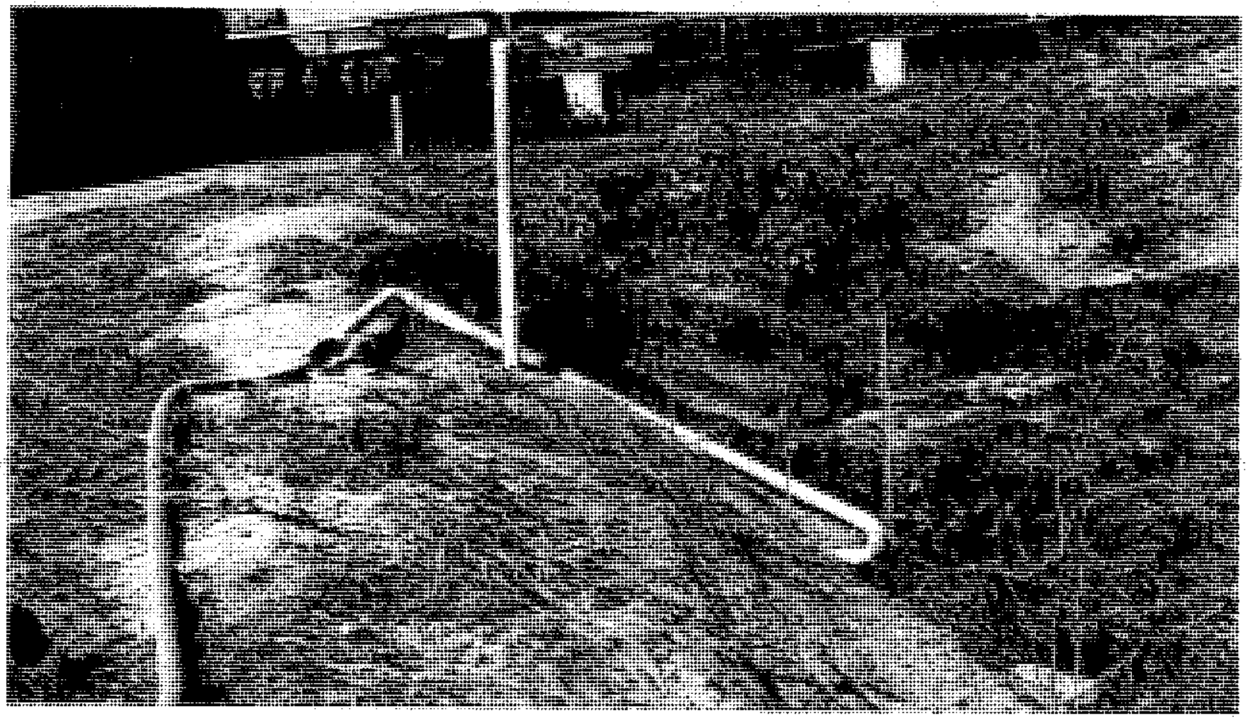
The geotextile tubes are sewn together. There is a seam at both ends and down the underside of the geotextile tube. The bags used in this project had two ports and depending on the size of the tube, they often have more ports. The port is made of typical plumbing parts. This port is where the tubes are filled. Once they are filled to 36" high, the lid is screwed back into the port and the tubes are left to dewater. The port is seen in the next picture.



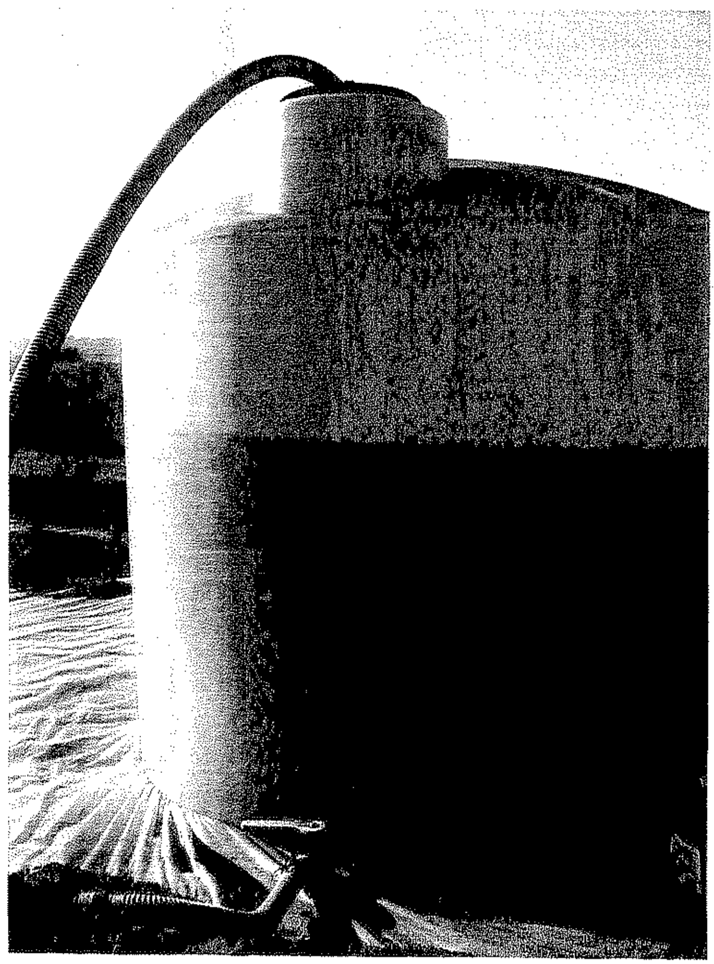
For this experiment, the first step was to grade the area to drain into the existing holding area. For a timeline of the projects steps and events see Appendix A. The grading was done by a local contractor with a bulldozer. After grading, plastic was laid down and sand was shoveled on the edges. This created a berm that directed any filtrate or runoff into the holding area. If this was to be a permanent geotextiletube dewatering area, the tubes would be placed on concrete. The concrete would need to be graded to drain to the holding area. Seen next is the bulldozer grading the geotextile tube area.

Pictured below are Brian Mastin and Mike Broering placing a geotextile tube. The plastic bed and sand berm are also seen in this picture.

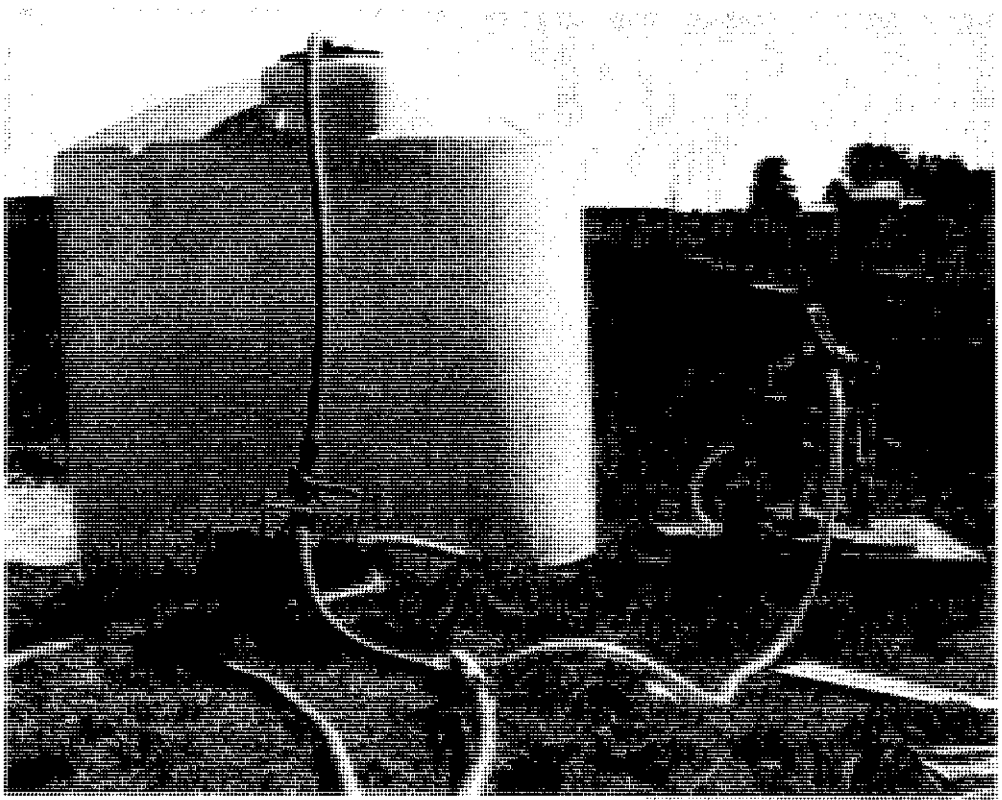
Pumping manure into the geotextile involved several steps. Each step must be performed or the floc will not form properly and the tubes will not dewater at the expected rate. Floc is short for flocculate, the particles formed when polymer is added to the manure. Seen below is the pipe directing manure to the geotextile tube project. Typically the swine barn pit is pumped on a float system. This system pumps manure into the holding area when the pit below the swine floor reaches a specifically designated depth.



The manure traveled through the green hose to the measuring tank, pictured on the right. The measuring tank was used for the experiment. For a full scale geotextile tube project, the manure would need to be measured in some way. The tank may not be the optimal way to measure the liquid manure. Even in this short experiment it began to form a crust and the solids began to sink; thus it required agitation before every pumping.



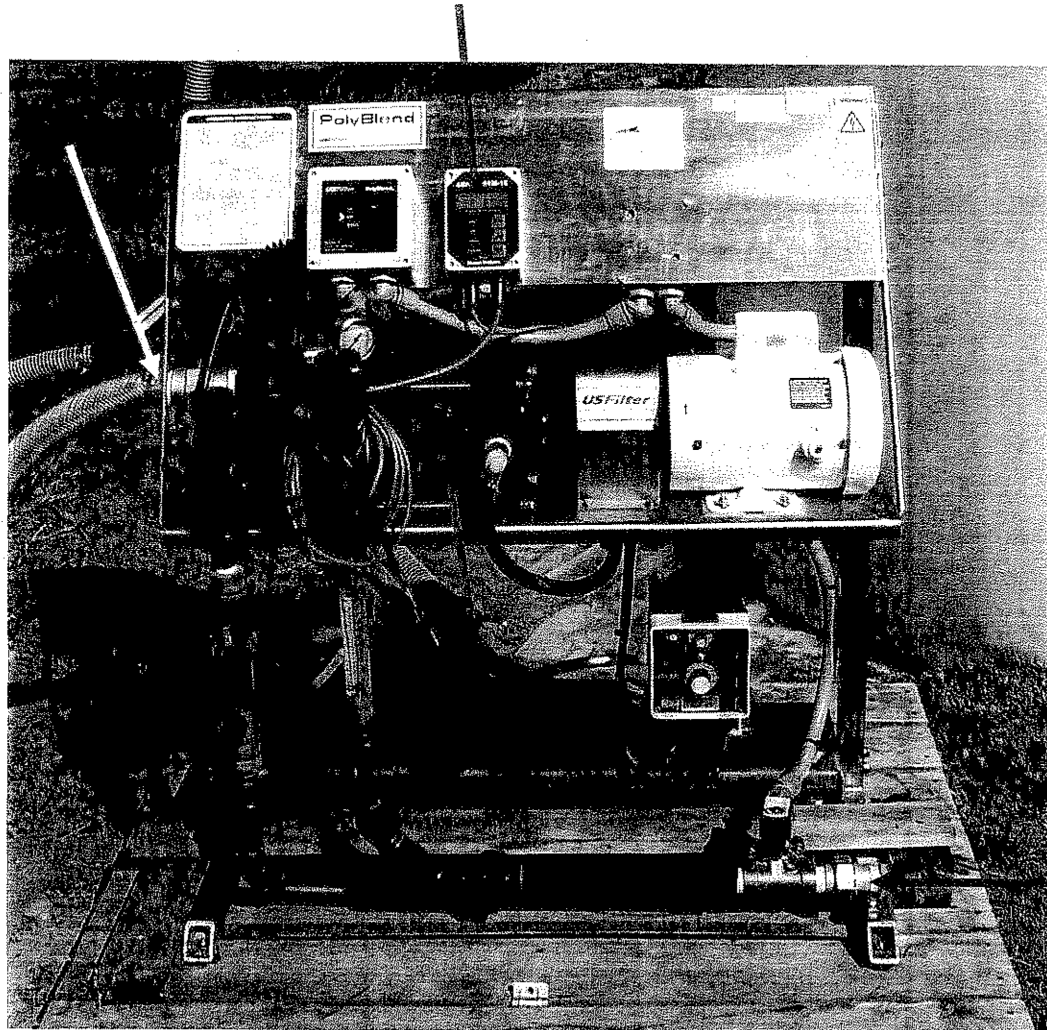
The next picture explains how manure is pumped into the tubes. Manure comes from the swine facility, being pumped by the existing pump from the holding pit below the facility. This is the hose running into the top of the measuring tank. Next the manure was measured. For the experiment, it was marked on the tank. When it was time for filling to begin, the valve at the bottom of the tank was opened and the trash pump started. The trash pump moved manure from the tank to the hose where it would be combined with polymer. In the picture below, the polymer pump is located to the right of the trash pump and measuring tank. See below for more information on the polymer pump. Also seen in this picture is the hose running to the actual geotextile tube.



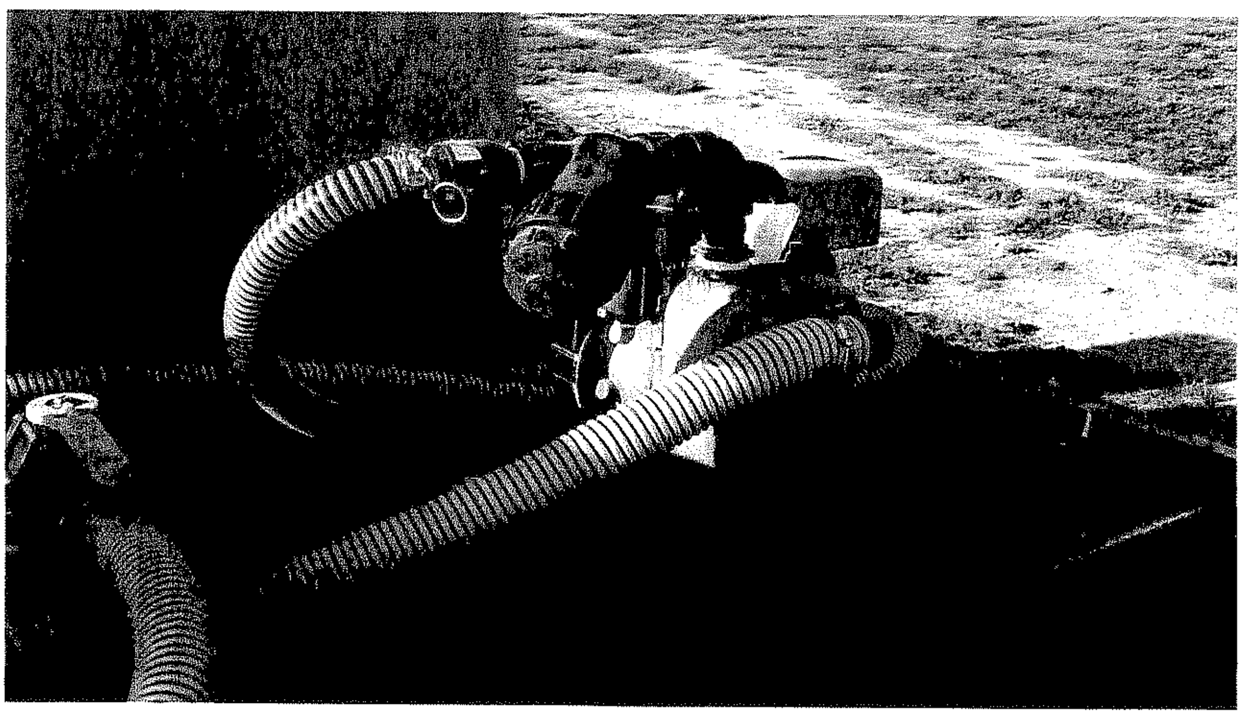
The polymer pump is actually called a make-down unit; it can be seen in the following picture. This unit took concentrated polymer and adds water, creating the made-down polymer needed to create floc in the geotextile tubes. The make-down unit was utilized to ensure a good mix of polymer was being supplied. Clean water was supplied with another tank and trash pump. Polymer can be shipped in "neat" form, concentrated, typically in 5 gallon buckets or already made down in large totes, ready to use. For this experiment, 5 gallon buckets were used. A make-down unit is expensive for purchasing or renting and has the possibility of breaking down. It is possible, with further experimentation, that surge pumps could be used for pumping the polymer. These pumps are inexpensive and producers are familiar with how they work. A make-down unit requires training and would be something new for the producer to learn.

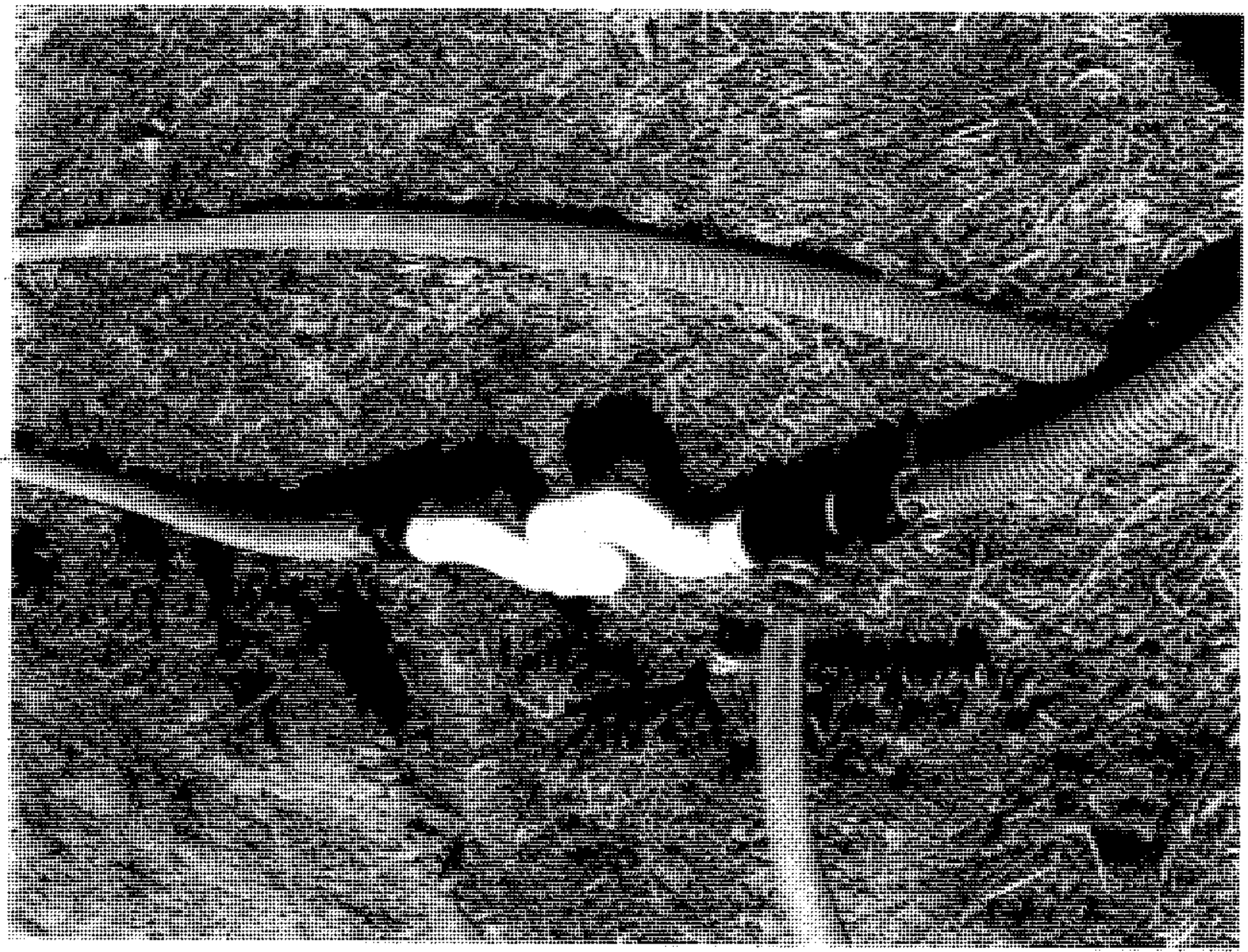
The make-down unit, pictured below, must be supplied with pressurized clean water, as denoted by the red arrow. One can see the polymer combined with the water in the clear tube area, shown by the green arrow. The polymer solution can be seen exiting the make-down unit at the yellow arrow.

Once the polymer is mixed and combined with the manure, it must be checked. This check is to see if the polymer is creating good floc. If the floc is not good (more details later), then the polymer can be increased or decreased, by using the push-buttons, shown by the blue arrow. The make-down unit must be ran by electricity. For the experiment, electricity was supplied from a nearby barn. Another requirement for the make-down unit is flushing with water after every pumping. The polymer is a very sticky substance and will quickly clog any pipe or machine if not thoroughly rinsed.



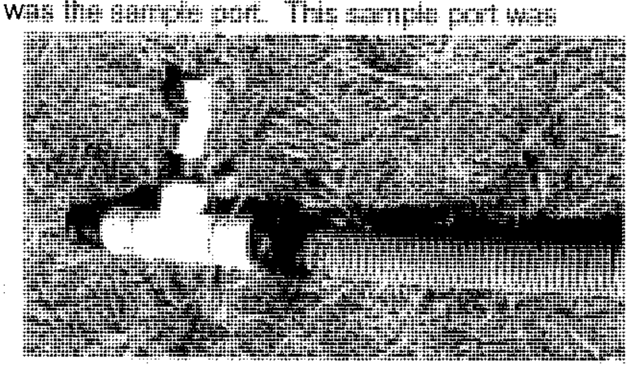
Clean water was supplied by wagon, tank and pump, pictured below.

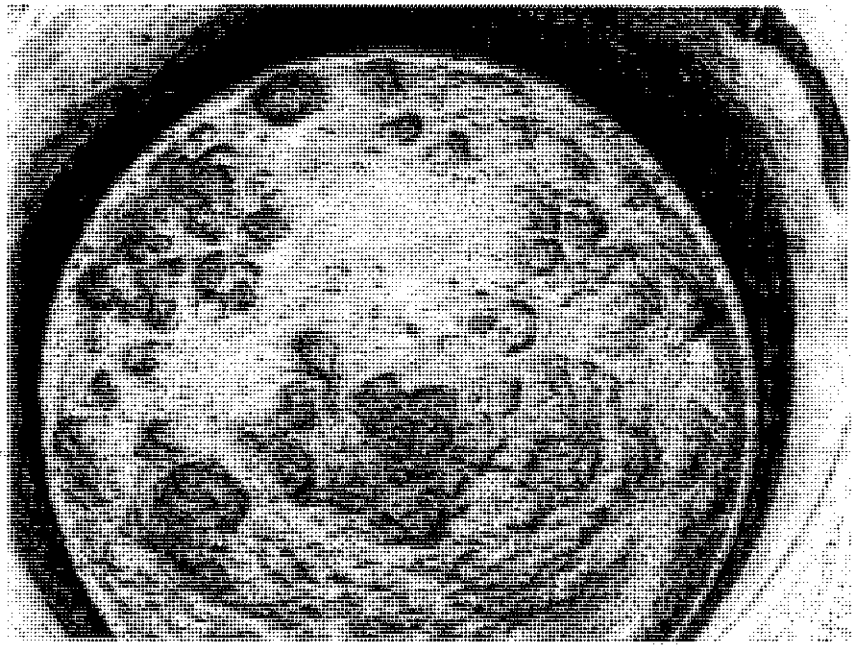




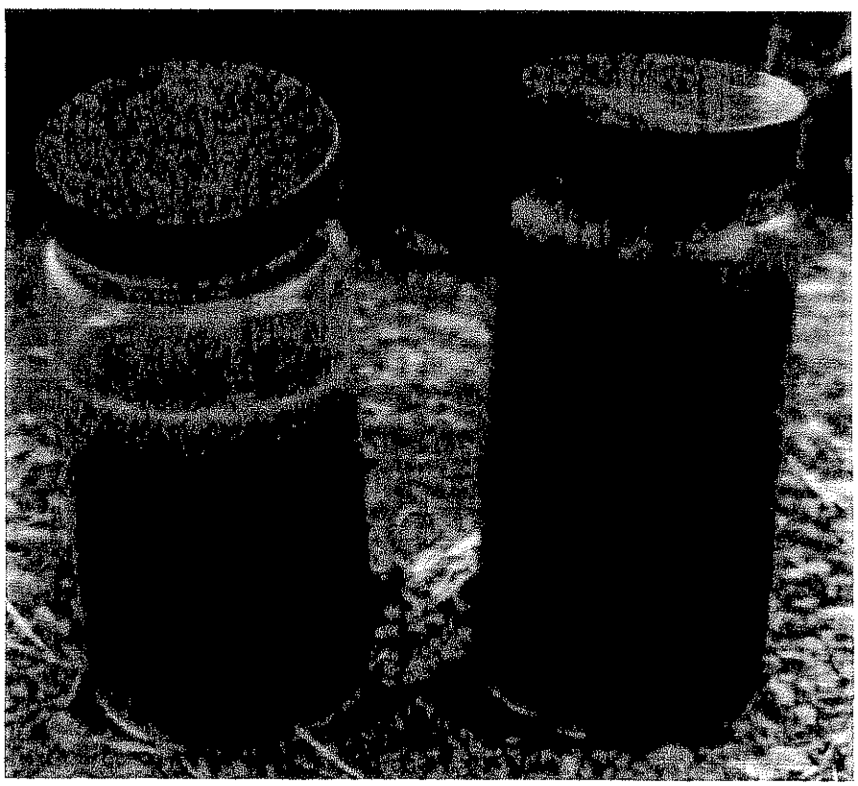
The above picture shows the mixing tube. This tube was created from everyday plumbing hardware to mix the polymer and manure. The polymer (already mixed with water) comes from the clear tube and the manure (already measured) came from the green hose attached near the clear tube. The two parts traveled through the "s" mixing tube, were mixed and traveled through the green hose off the left side of the picture. The green hose running through the entire picture was the manure supply hose.

Between the mixing tube and the geotextile tube was the sample port. This sample port was where the floc was checked. Seen to the right is the sample port, before it was connected to the geotextile tube supply hose. Again, this was made out of simple plumbing parts.

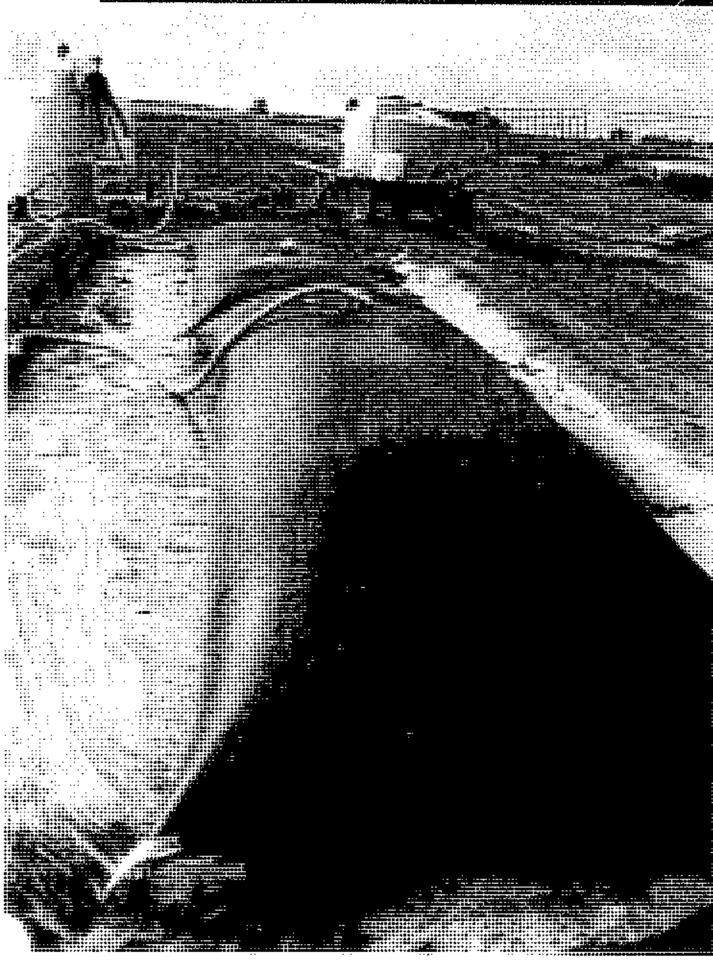




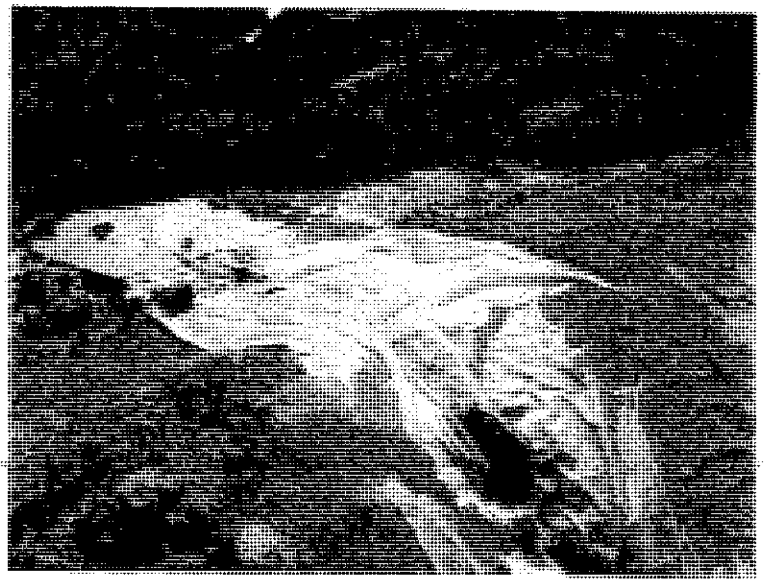
Seen to the left is a bucket taken from the sample port. This bucket contains large floc; therefore the polymer was reduced. Good floc can be seen in the jar samples, pictured below. The jar on the right was taken from the sample port and allowed to settle. By looking closely, one can see floc sinking to the bottom of the jar and floating to the top. The jar on the left is filtrate, is the liquid released from the geotextile tube. This liquid is still too high in nutrients to be released. It travels down the plastic to the holding area (see later picture).



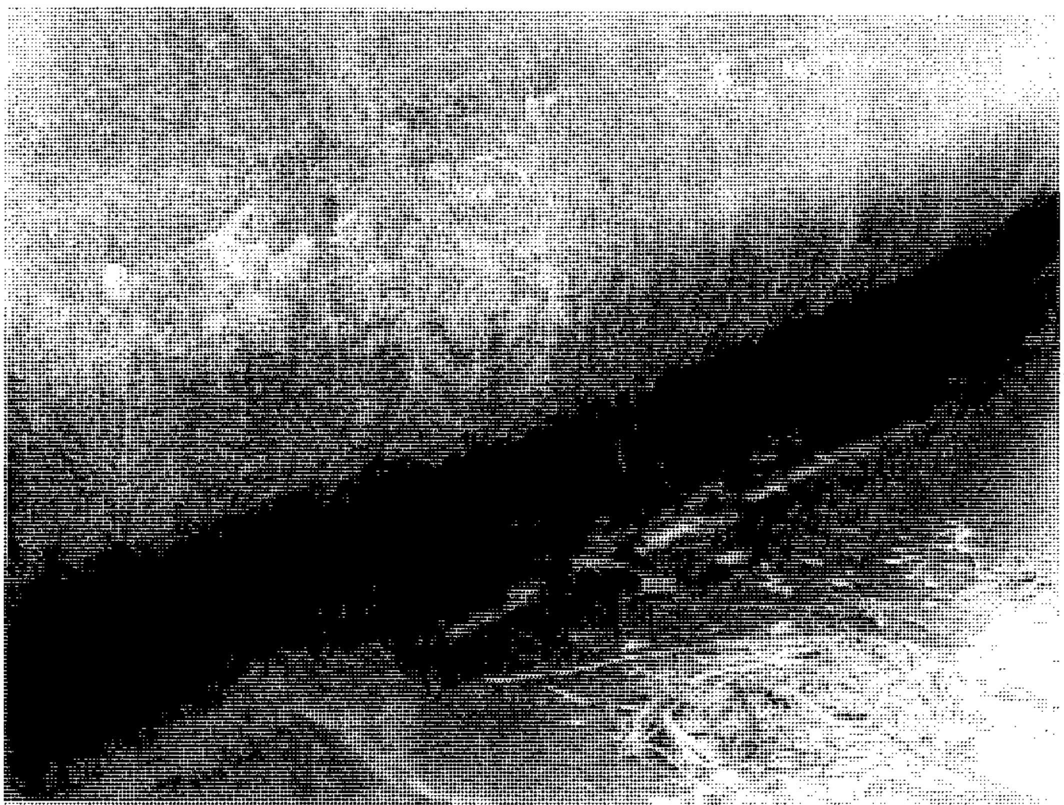
On the first day of pumping, Mercer County SWCD brought their county officials tour to the swine facility site. Seen below is news reporter, Nancy Allen, *The Daily Standard,* and several county officials.



The picture to the right was a typical day of pumping. Mr. Broering is checking the tank to see how much manure is left to pump.

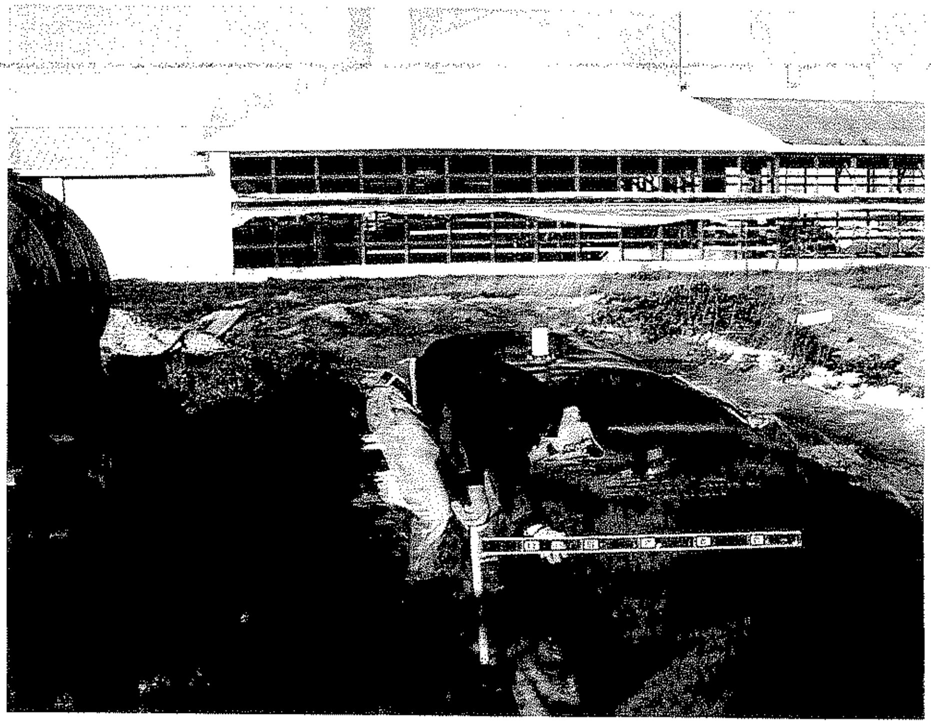


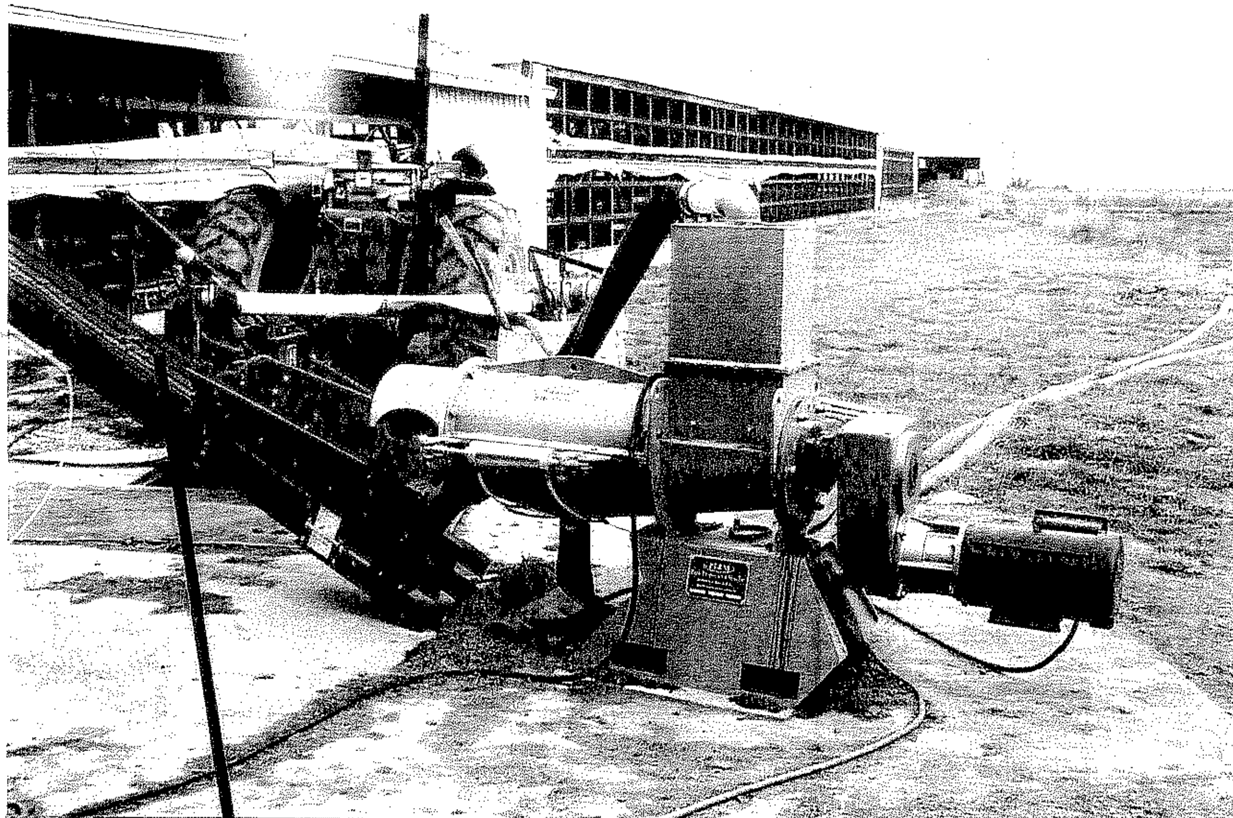
The picture to the left shows the filtrate running into the holding area. As you can see, the plastic and sand prevented it from seeping into the ground.

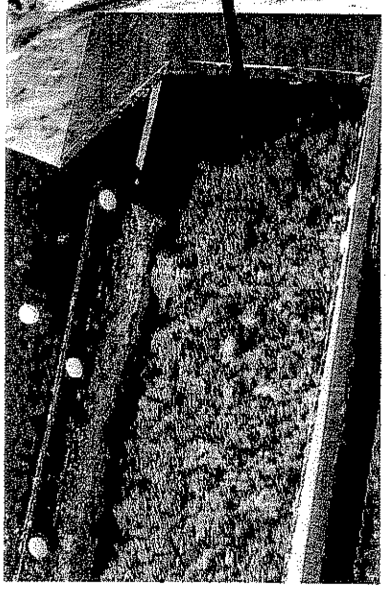


This picture shows a "pee'er". This happened when the pressure inside the geotextile tube was high enough to shoot a stream out the side of the tube. This often happened at the ends of the tubes, as well. More pictures of this can be seen in Appendix B .

For the experiment, the tubes were measured before and after every pumping. For a full scale project, this would not be required, but recommended. By measuring the height of the tubes, the producer would know when the tubes were close to full and how quickly the tube was dewatering. Seen below is Mr. Broering measuring at the second site for the experiment. This second site was at a dairy farm.







At this dairy farm, the producer utilized a manure separator. This screw press, pictured below, separated some of the solids from the liquid manure. These solids are moist, light and fluffy, as they travel on the conveyor over the barn. The solids are then composted (pictured on the next page) and reused as bedding. This is a benefit to the producer. The cows are more comfortable, so they produce more milk. The producer is also saving money, as bedding no longer needs to be purchased.

There is little to no difference in the geotextile tube pumping process for the dairy facility. The polymer utilized was different than the polymer utilized at the swine facility and dewatering seemed to be different for the experiment. The different polymer was used to separate more dissolved nutrients from the effluent from the manure separator. This did not change the pumping process. The dewatering seemed to go slower at the dairy facility. At the swine facility, the filtrate could be seen sheeting off the geotextile tube while the tube was being filled. At the dairy facility, the water was released only when the tube was kicked or hit with a board. Over time, the dairy facility tubes seemed to hold water. When pressure was applied by standing on the tube and then removed, a puddle would form in the footprints. (Pictures can be viewed in Appendix B.) The geotextile tubes still accomplished the goal, reducing nutrients in the filtrate and dewatering the manure, but there are still many questions left unanswered. There is a definite need for more experimentation at a dairy facility. At this time, the only logical explanation is in what the animals eat. Cows consume more fiber and leafy materials and swine consume more grain.

Secondary objectives:

A secondary objective was to demonstrate that the addition of flocculants and conditioners can precipitate out the dissolved phosphorus in the liquid manure so that it is retained in the geotextile tube. Results showed the geotextile tubes retained over 99 percent of the phosphorous with the solids. However, there is still a significant concentration of phosphorus in the filtrate. Total Maximum Daily Load (TMDL) studies completed in the Grand Lake St. Marys and Wabash River watersheds outlined the TMDL for phosphorus at 0.17mg/L. Results indicated an average of 126 mg/L of phosphorus in the filtrate at the hog operation. At the dairy operation, phosphorus levels in the filtrate averaged 29 mg/L. Neither of these nutrient levels is close to dischargeable levels. This requires the filtrate to be routed into a storage area.

The TMDL for total nitrogen is 1.5 mg/L. Results indicated an average of 2,300 mg/L of total nitrogen in the filtrate at the hog operation, and an average of 605 mg/L of total nitrogen in the filtrate at the dairy operation. These results also show that the filtrate could not be directly discharged to waters of the State without further treatment. Therefore, all filtrate would need to be collected in a storage area on the farm and treated as liquid manure or irrigated on standing crops. Irrigation on standing crops would require additional infrastructure at a facility, requiring additional costs to the landowner.

Another secondary objective was to demonstrate that the geotextile tubes can provide additional storage space for manure during periods when inclement weather precludes its application to fields to remain in compliance with Natural Resource Conservation Service (NRCS) standards.

As Dirksen reported, geotextile tubes are an effective way to supplement traditional manure storage. At the swine facility, pumping was done before the large hogs were shipped out and again when there were small hogs. The experimental size tubes were able to keep up with the manure production of the small hogs, but not with the large hogs (approximately 500 hogs). With larger tubes, it would be possible to pump all the large hog manure into the geotextile tubes. If all the manure went through the geotextile tube process, approximately 58.5% of the total solids would be captured.

At the dairy facility, significant manure storage space was saved by utilizing the mechanical solids separator. On average the separator saves 18% of the storage space by removing the solids from the liquids. This process also provides bedding for the cows and increases their milk production. The actual space saved by utilizing geotextile tubes at this facility was nominally above this, because the majority of the solids held in the geotextile tubes were dissolved in liquid coming from the separator. The polymers separated a significant amount of dissolved nutrients from the water. The utilization of the separator reduces the volume going into the holding area, thus creating space for surface runoff from the geotextile tube placement area.

If the manure storage area is a covered structure and the area where the geotextile tubes are placed is a covered area, the amount of storage space saved would be even higher. Having a covered storage area is not typical of the producers in the Grand Lake St. Marys and Wabash River watersheds. The majority of the producers have a traditional storage area, similar to a pond or holding tank. When the geotextile tubes are placed, the filtrate and surface runoff must be captured in the storage area. This means that the producer is saving storage volume by not pumping manure into the holding facility, but is losing area by collecting the surface runoff from the geotextile tube placement area. Geotextile tubes can provide additional storage space for manure during periods when inclement weather precludes application; however the exact amount of savings will be determined by precipitation.

A third secondary objective was be to analyze the effluent from the geotextile tubes to determine if it could meet standards for direct discharge to waters of the State with minimal additional treatment or if it could be used for other purposes by the producer. With the polymers utilized in this project, the filtrate must be captured in a holding area. As noted earlier, Dirksen reported it is possible to irrigate this filtrate onto a growing crop; however, data observations show that the filtrate could not be discharged to waters of the State. For details on the average levels of nutrients, see Appendix C. A drop is shown from the raw manure, but the filtrate levels are still too high to be discharged.

Different polymers can be used to pull out more nutrients and create a cleaner effluent. This is possible, but would increase the distance to achieve economic feasibility. If this option was chosen, and after scrutiny by Ohio EPA, it may be possible that a general NPDES permit could be distributed to operations wanting to discharge this liquid. Achieving this objective would definitely take more experimentation, including bench tests and a full scale project.

The final secondary objective was to compare the effectiveness of the geotextile tubes between dewatering liquid hog manure and liquid dairy manure. Three tubes were used at the hog facility, and two geotextile tubes were used at the dairy facility. The dairy facility used a mechanical manure separator as well. This separator extracted the solids from the liquids in the dairy manure. The liquids then go into the holding facility, and the solids are composted and later re-used for bedding in the dairy stalls. Due to the nature of the dairy manure and the liquid coming from the separator, more flocculants were needed to remove the solids. After reviewing data and observations, it is concluded that geotextile tubes are more effective at handling hog manure than separated dairy manure in this situation. Variables to be considered with this conclusion include the following: what the animals eat and digest, operator/human error, separator malfunction and polymer under/overdose.

Appendices

Appendix A: Project Action Plan and Timeline

September 2007 – Contracts were developed for the producer's participation, the testing of the liquid manure and effluents, and the supplier of the geotextile tubes and conditioners. The contracts were awarded by the Grand Lake/Wabash Watershed Alliance to the testing lab and the supplier of the geotextile tubes. Preliminary tests were conducted on the dairy and hog liquid manure. WaterSolve, LLC was able to determine the hog manure chemistry and dairy facility chemistry needed in the field. Ivo Post was selected as the hog producer and Randy Goettemoeller as the dairy producer. The geotextile tubes were installed adjacent to the producer's holding pond with the pumps and make-down unit (equipment that uniformly distributes the flocculants and conditioners). Mike Broering of WaterSolve LLC, assisted by the project team, pumped manure into the geotextile tubes on a regular basis. Each time manure was pumped, the tubes were measured and the amount of manure pumped was recorded. Samples of the liquid manure were taken before it was pumped into the geotextile tubes to determine the nutrient and solid content. Samples of the geotextile tube contents and effluent were also taken to determine their nutrient and solid content.

September 2007 through May 2008 – The tubes rested for approximately 180 days. Additional samples and measurements were taken throughout this time period.

Starting at the end of March and continuing through May 2008 – Weather permitting, the geotextile tubes were opened and the solids were used as a fertilizer in fields or in an environmentally friendly manner acceptable to the producer. Samples of the solids were taken to determine its nutrient and solids content. After this, the data collection was complete.

June 2008 - The project data was obtained. A report from the three parties was requested.

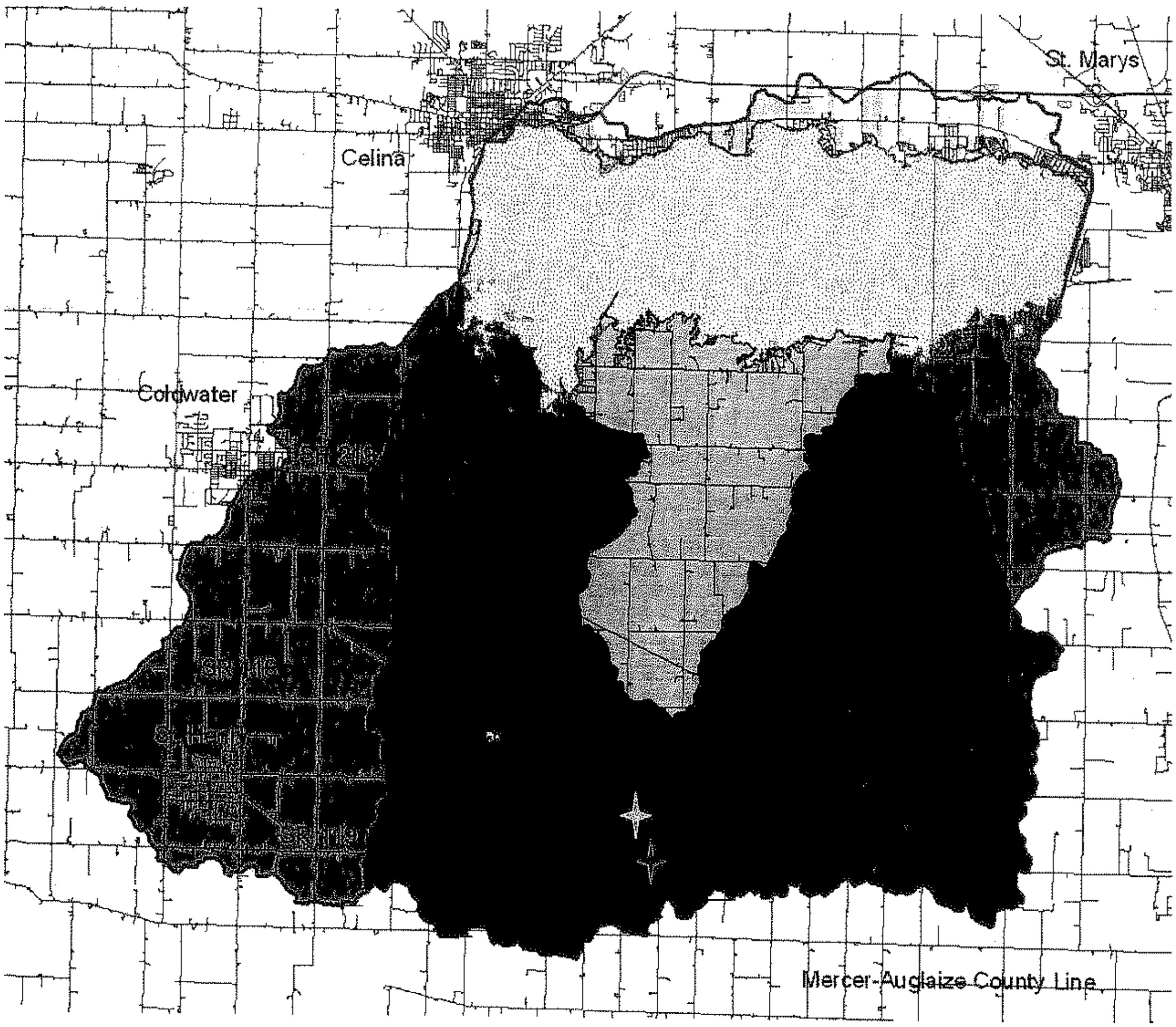
July 2008 – The project report was compiled.

August 2008 -- Report completed.

September 2008 - The project report will be shared with producers in the watershed area and to other groups as requested to encourage utilization of geotextile tubes for dewatering liquid manure.

Appendix B: Geotextile Tube Pictoral Log

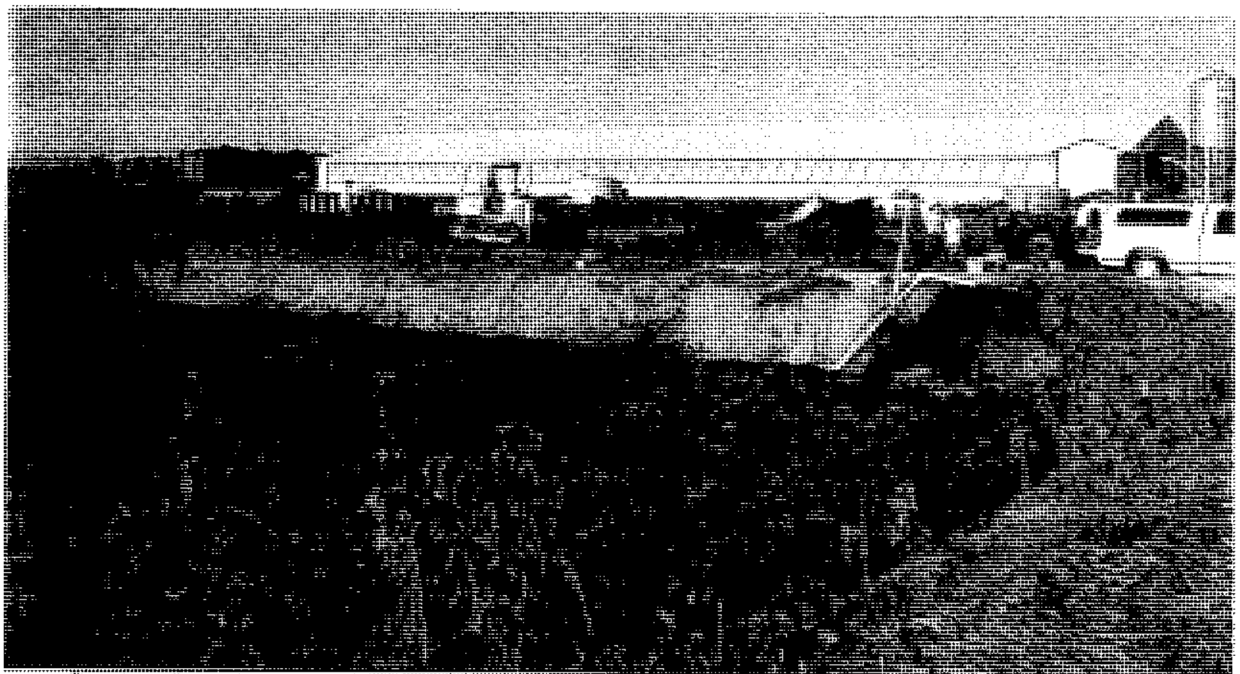
Site Locations



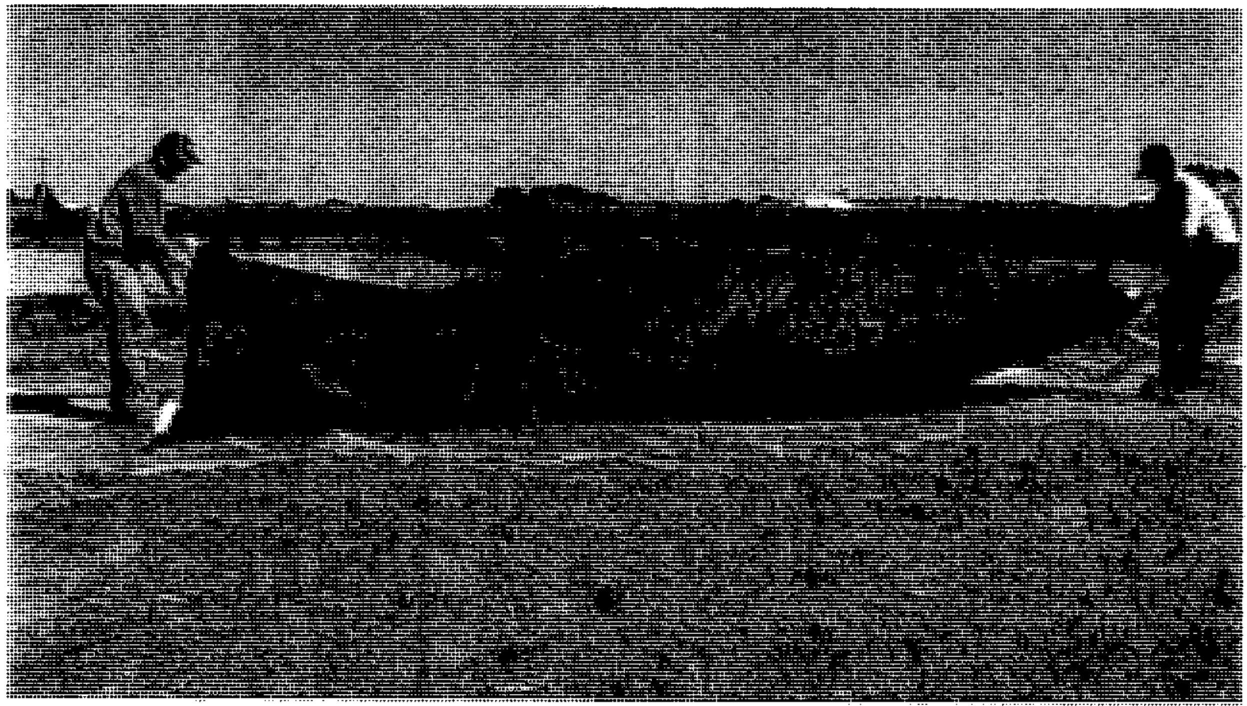
Grand Lake St. Marys Watershed Map, both sites are in the Beaver Creek Subwatershed

Location of Ivo Post Site

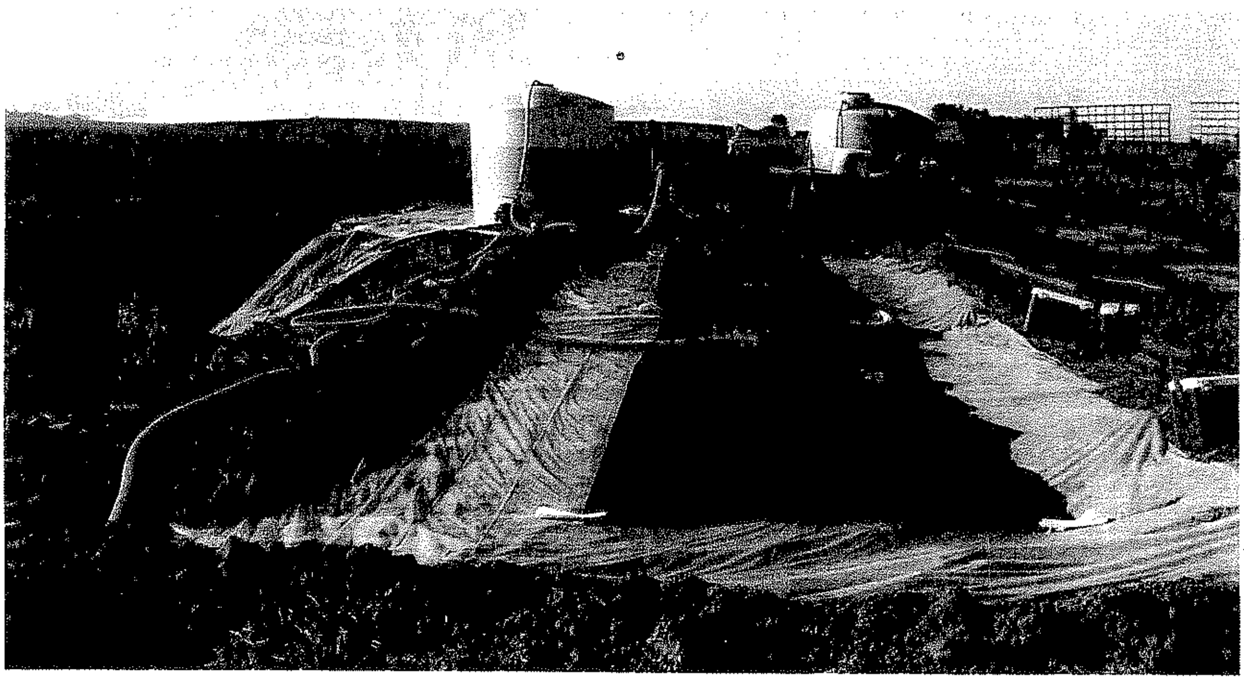
Location of Randy Goettemoeller Site


September 4, 2007 - Ivo Post Site, Bulldozer is grading so tube effluent runs into holding area.

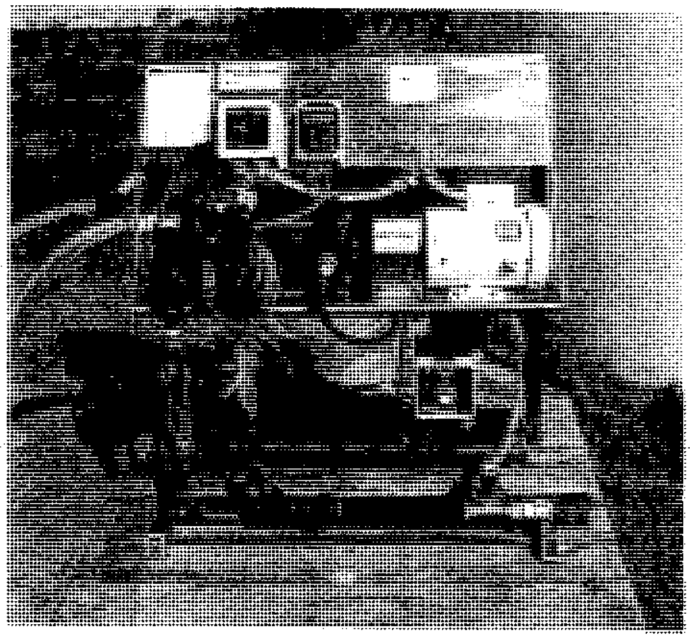

September 4, 2007 - Ivo Post Site, Manure Source



September 4, 2007 Brian Mastin and Mike Broering place the GT500 at the Ivo Post site. The Geotextile tube is placed on plastic for this experiment.

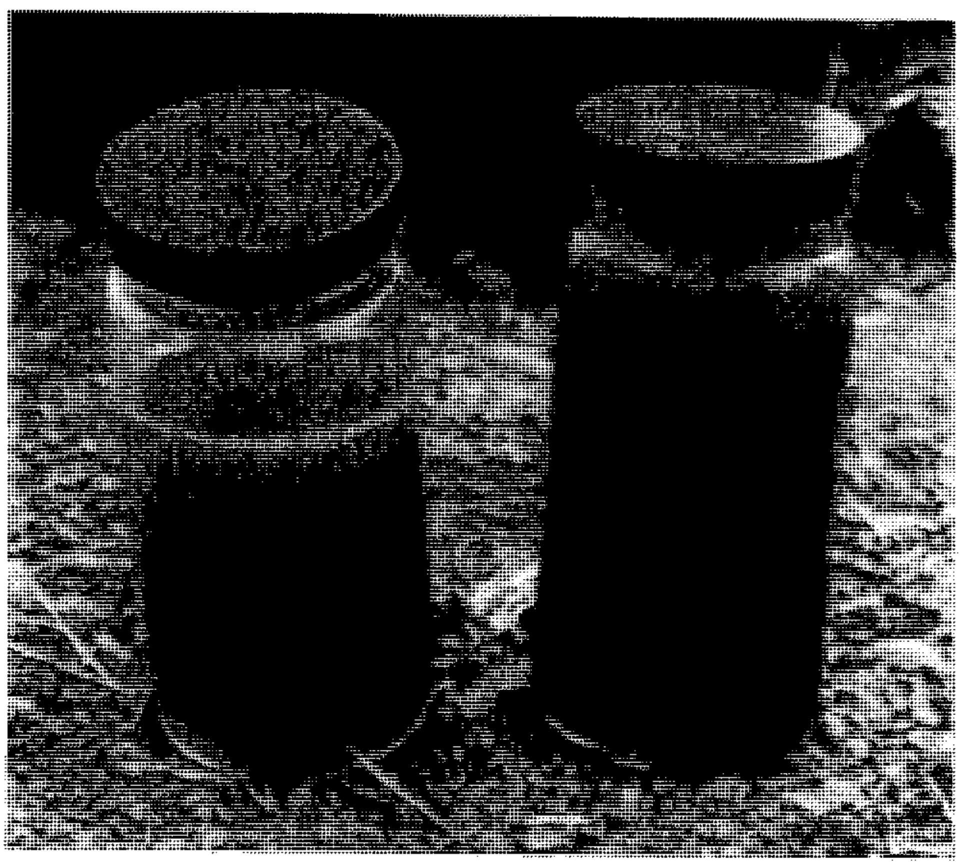


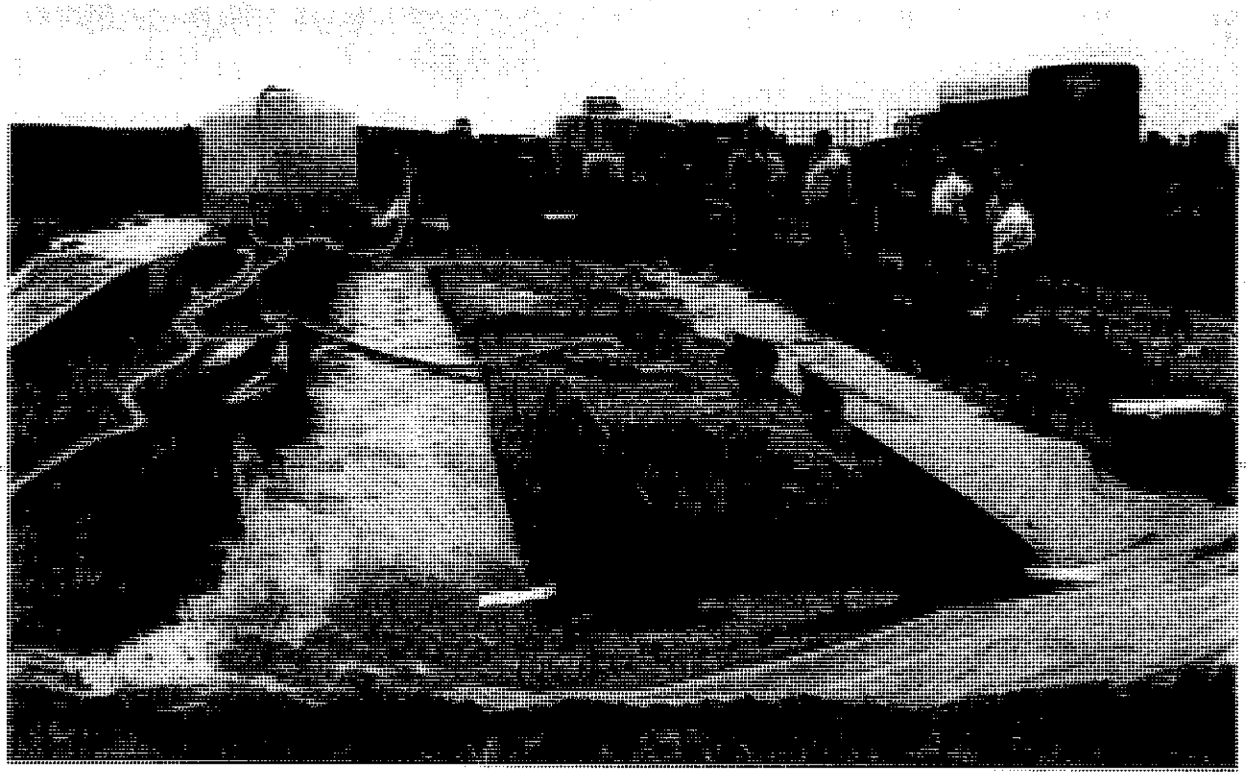
September 5, 2007 team prepares for first pumping at Ivo Post site.



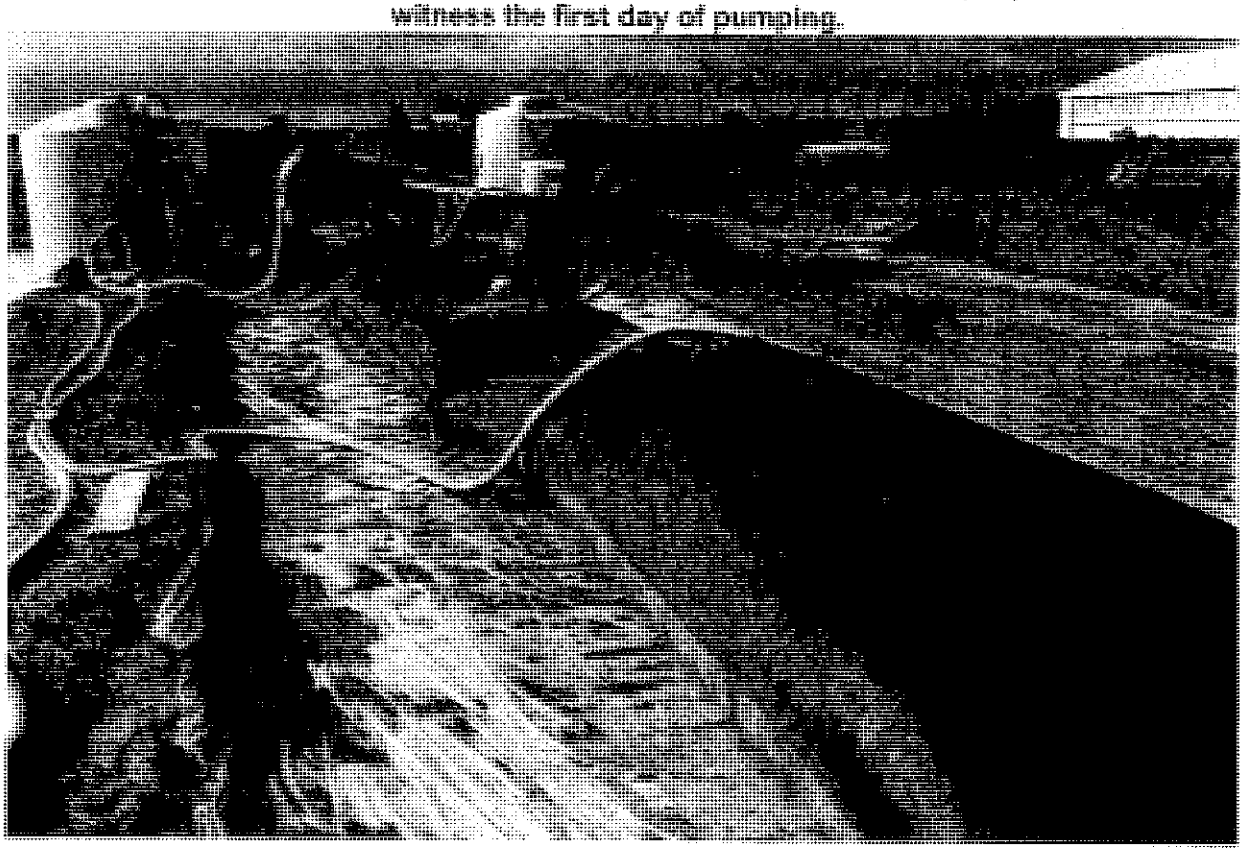
Pictured left is the make-down unit. This unit mixes the chemicals with water before it is mixed with the manure. This unit ensures an exact amount of polymer is used.

The jars pictured below contain matter from the September 6, 2007 pumping at the Ivo Post site. The jar on the left contains liquid, which was running out of the tubes. This liquid runs back into the holding area. The jar on the right is the manure and polymer mixture. This mixture goes into the tubes and the chemicals continue to bring the particles together as the liquid runs off. The picture shows how some particles float and some sink.



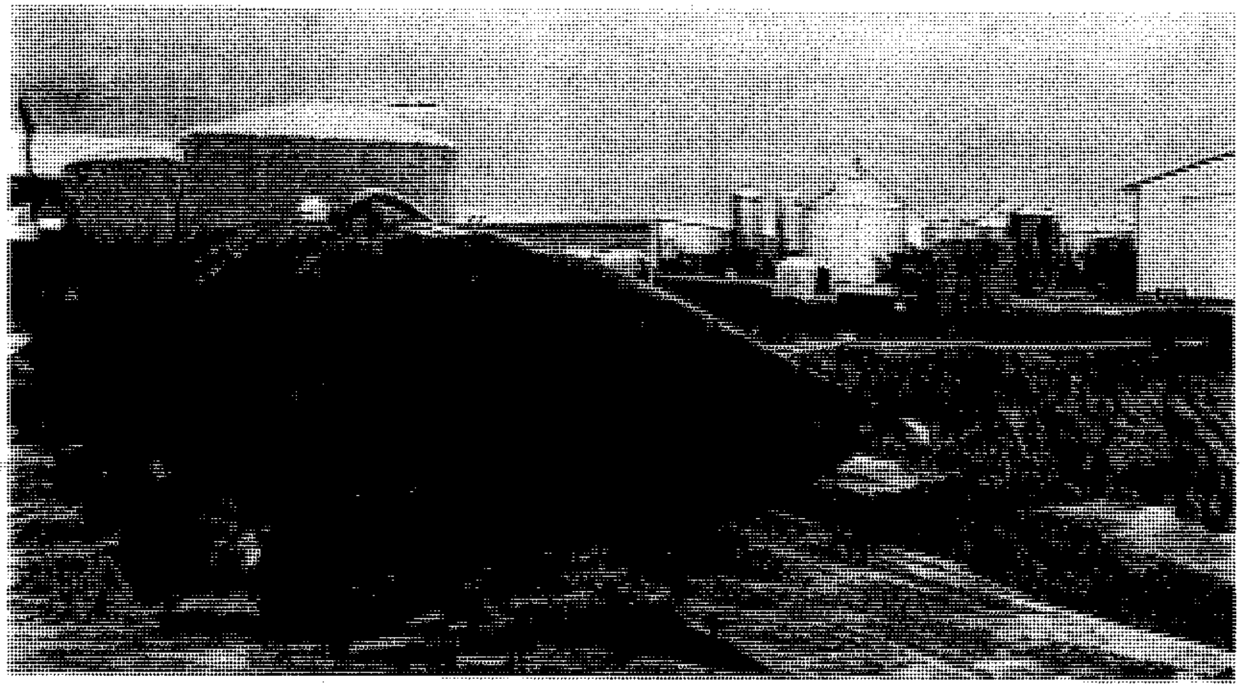


September 6, 2007 Public Official's Tour visits Ivo Post site. About 30 people were able to witness the first day of pumping.

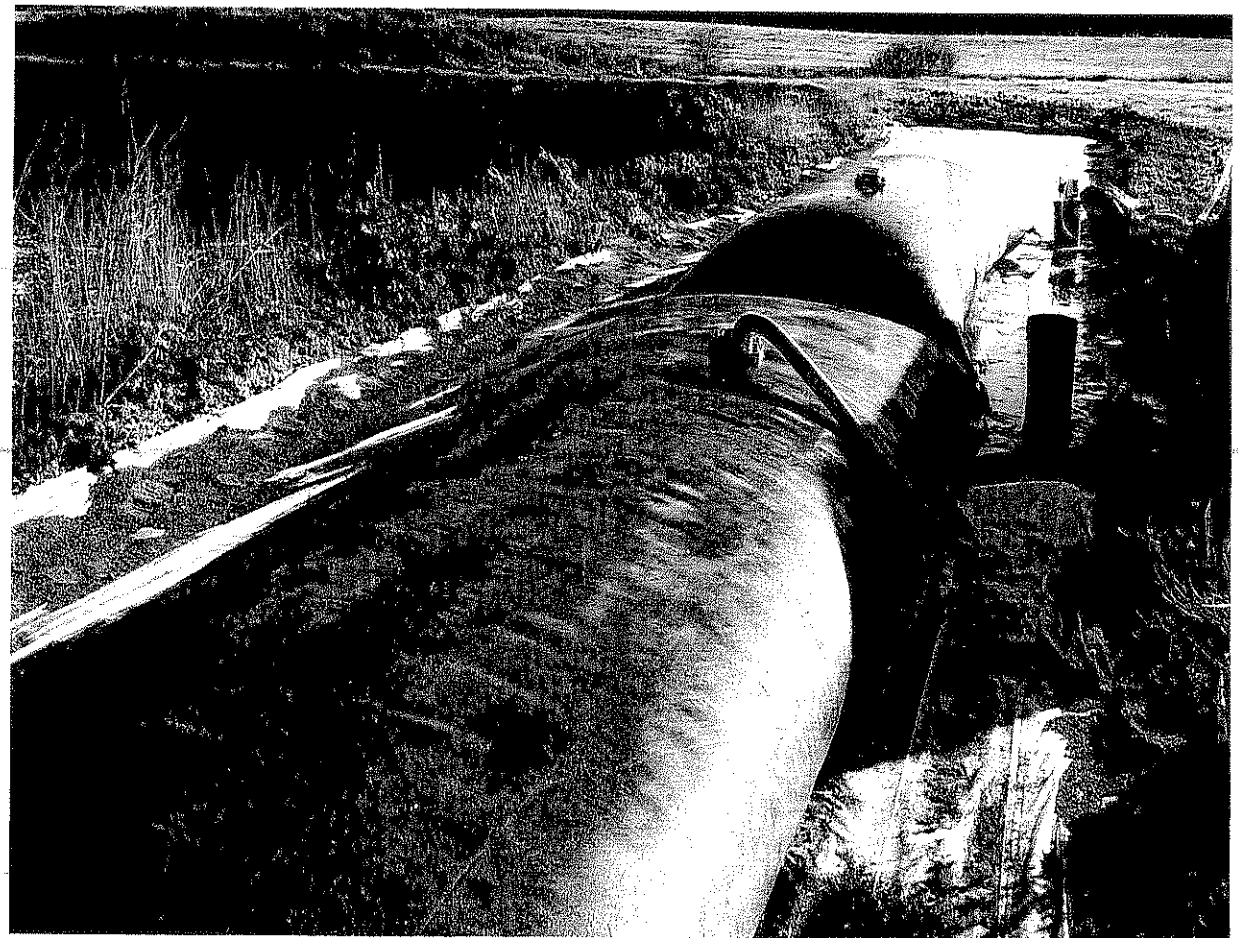


September 11, 2007 Ivo Post site after several pumpings. The GT404 was pumped to 32 inches and the GT500 was pumped to 29 inches. Before pumping on this day the GT404 was 19 inches tall and the GT500 was 13 inches tall.

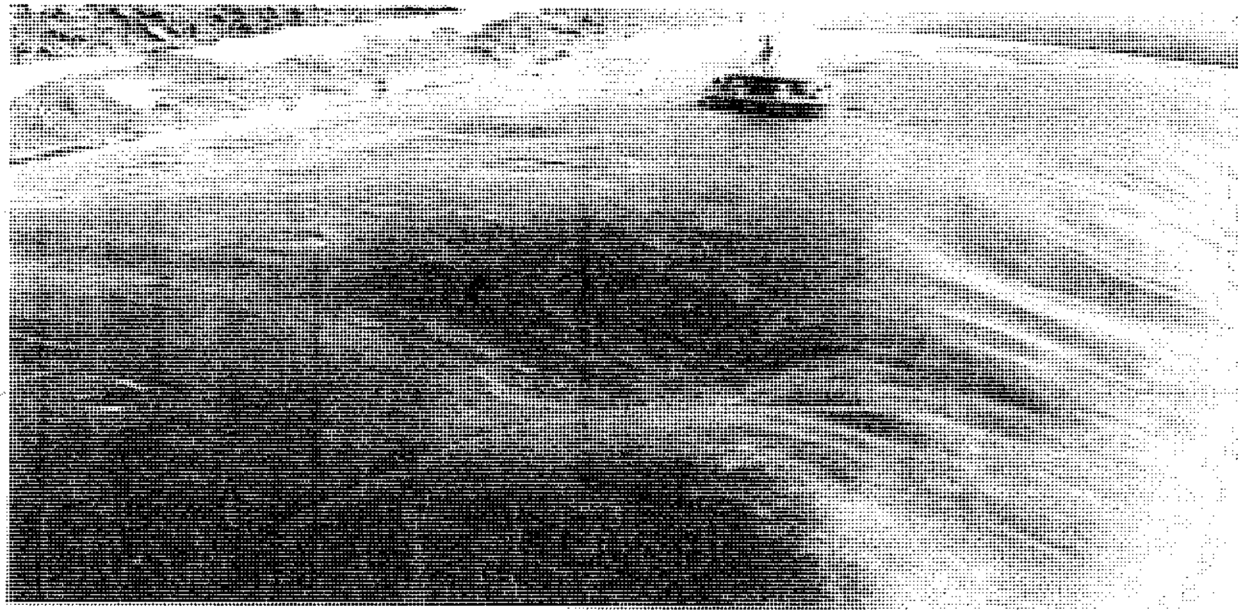
Above: Mike Broering taking the first core samples.
Below: On October 2, 2007, Broering walking on the tubes as they dewater.



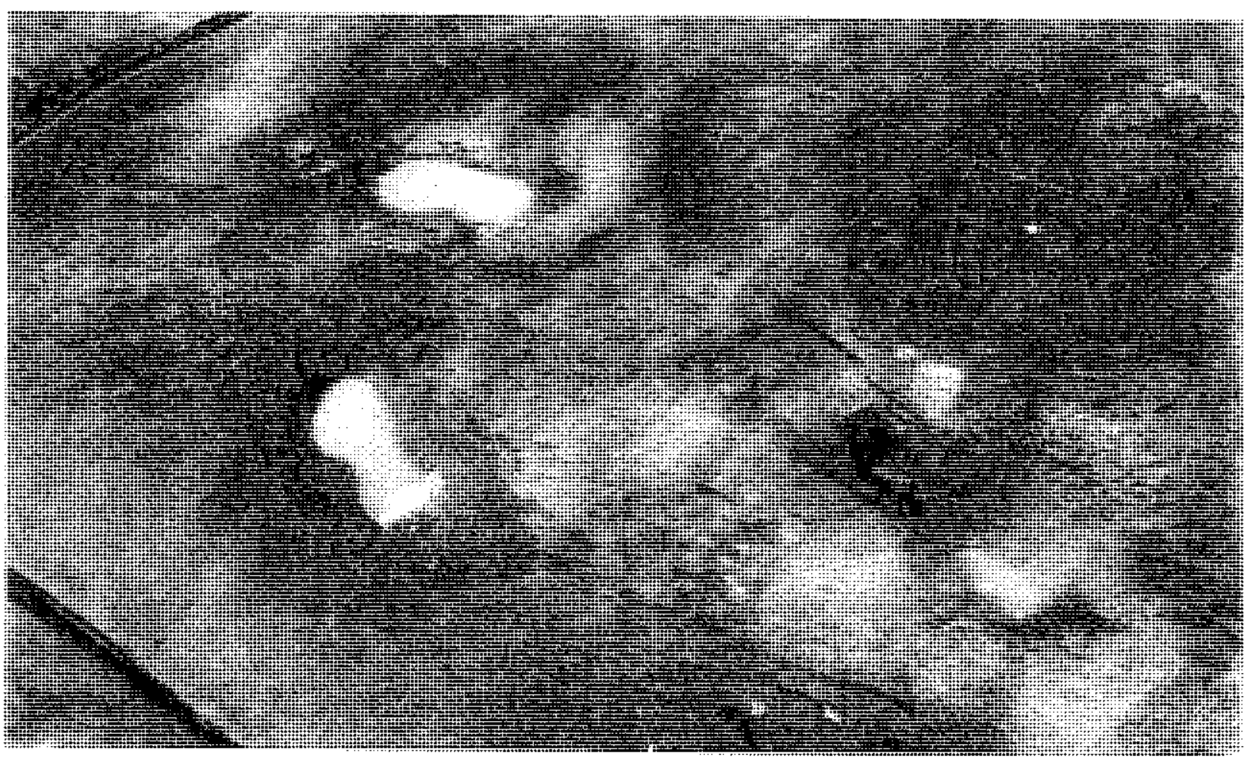
Above: October 11, 2007, pumping at third tube at hog tactility. The first two tubes are seen in the background.
Below: Same day, opening the first two tubes to take a core sample.

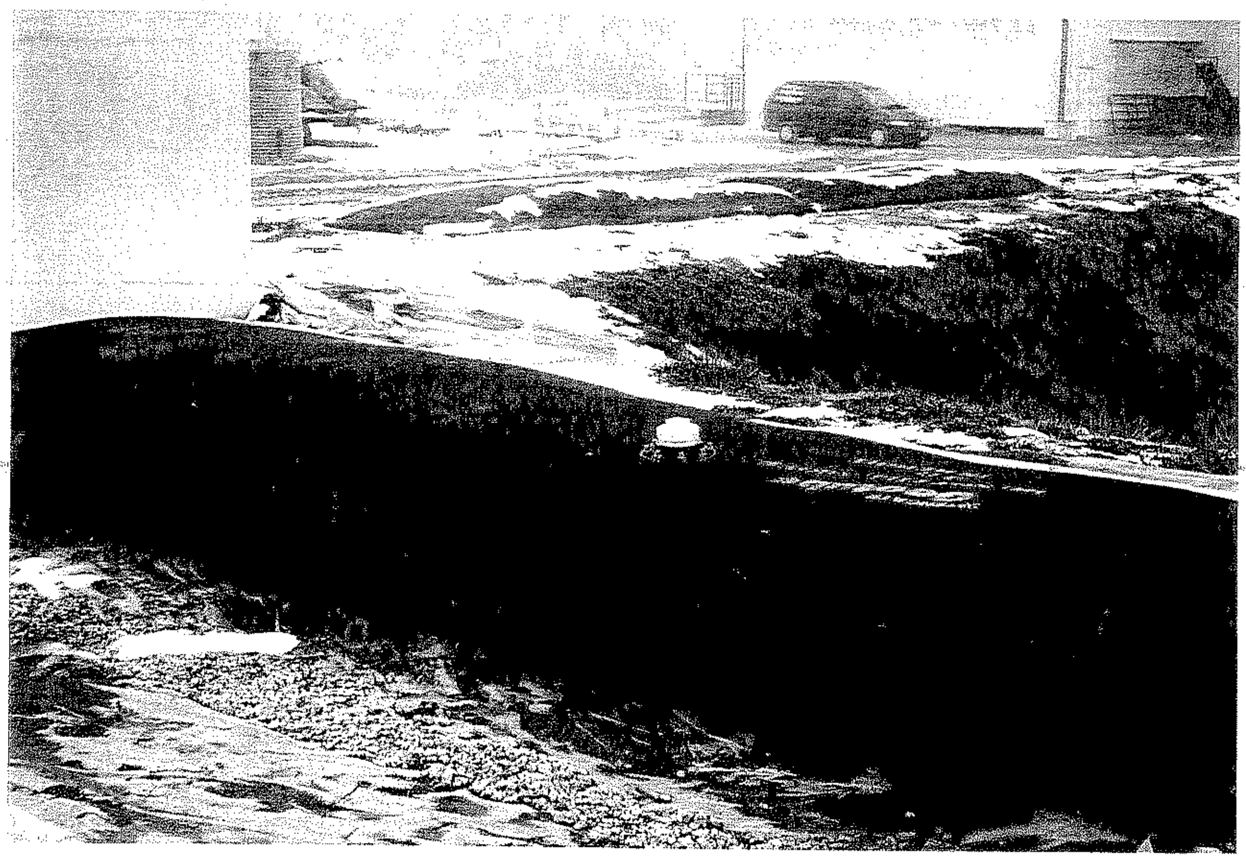


Top: October 29, 2007, pumping tubes at the dairy facility.
Bottom: On November 5, 2007, after pumping, effluent is seen leaving the bag under pressure. These are referred to as “pee’ers”. This also happens on the sides of the bags.



Above: November 14, 2007, tubes at the dairy are dewatering differently than the hog sites. At the above visit, water did not release after a person steps or stands on the tube. Seen below, five days later, when a person stands on the tube, the solids compress and water is released.

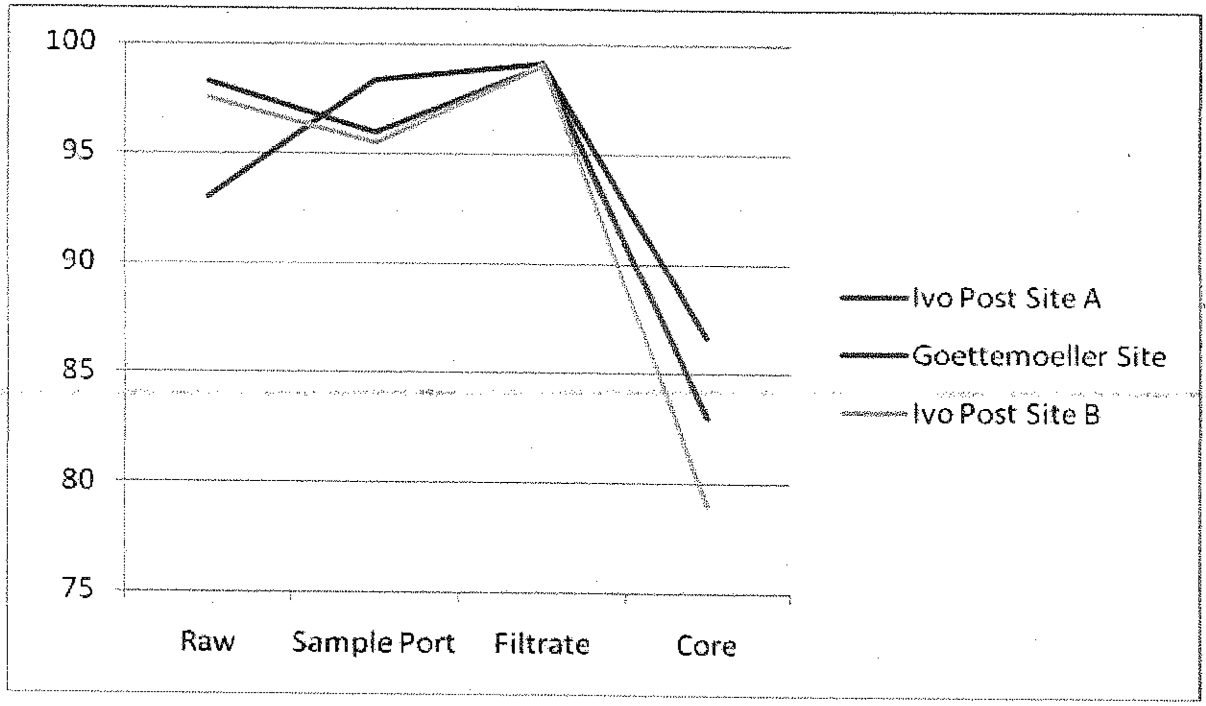




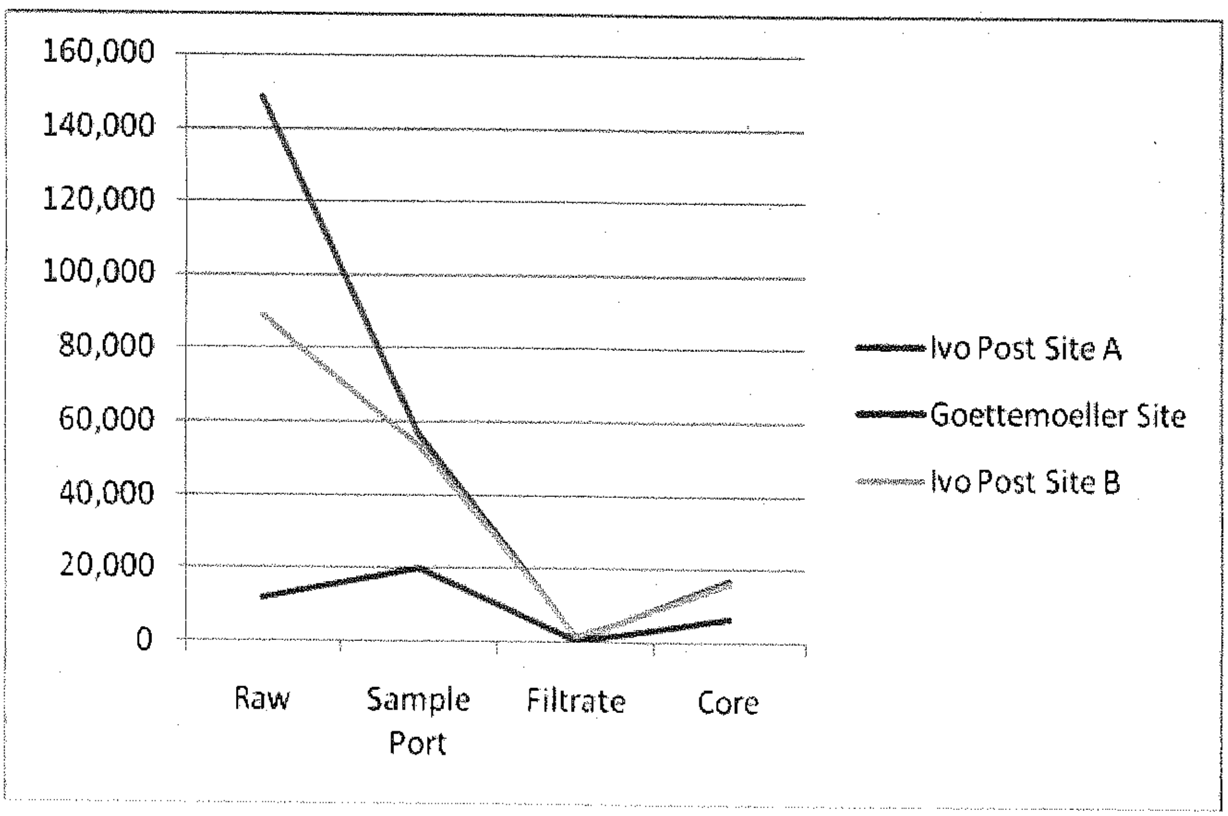
Above: December 11, 2007, tubes at the swine site are not all frozen. The third tube, seen in the front, is melting any snow that lands on it. Later in January all five tubes were snow covered and frozen.

Appendix C: Summary Charts and Graphs of Sample Data

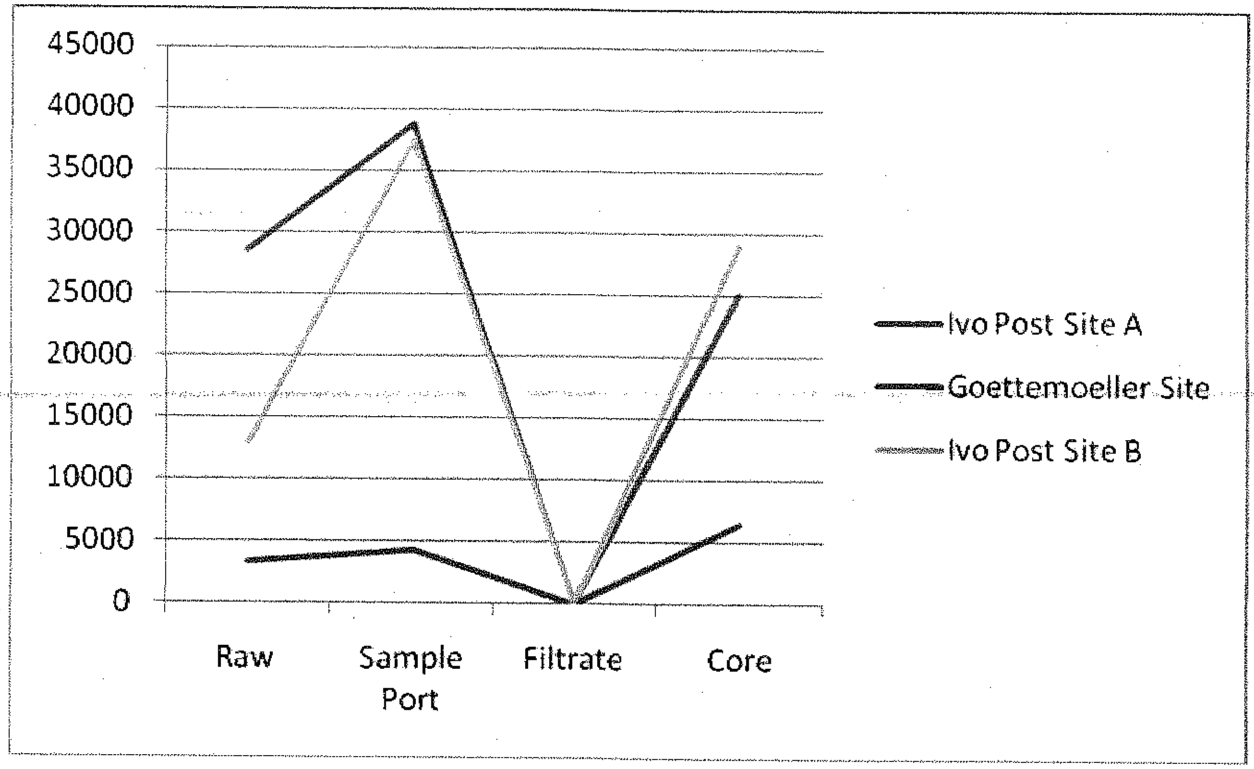
Average Percent of Moisture



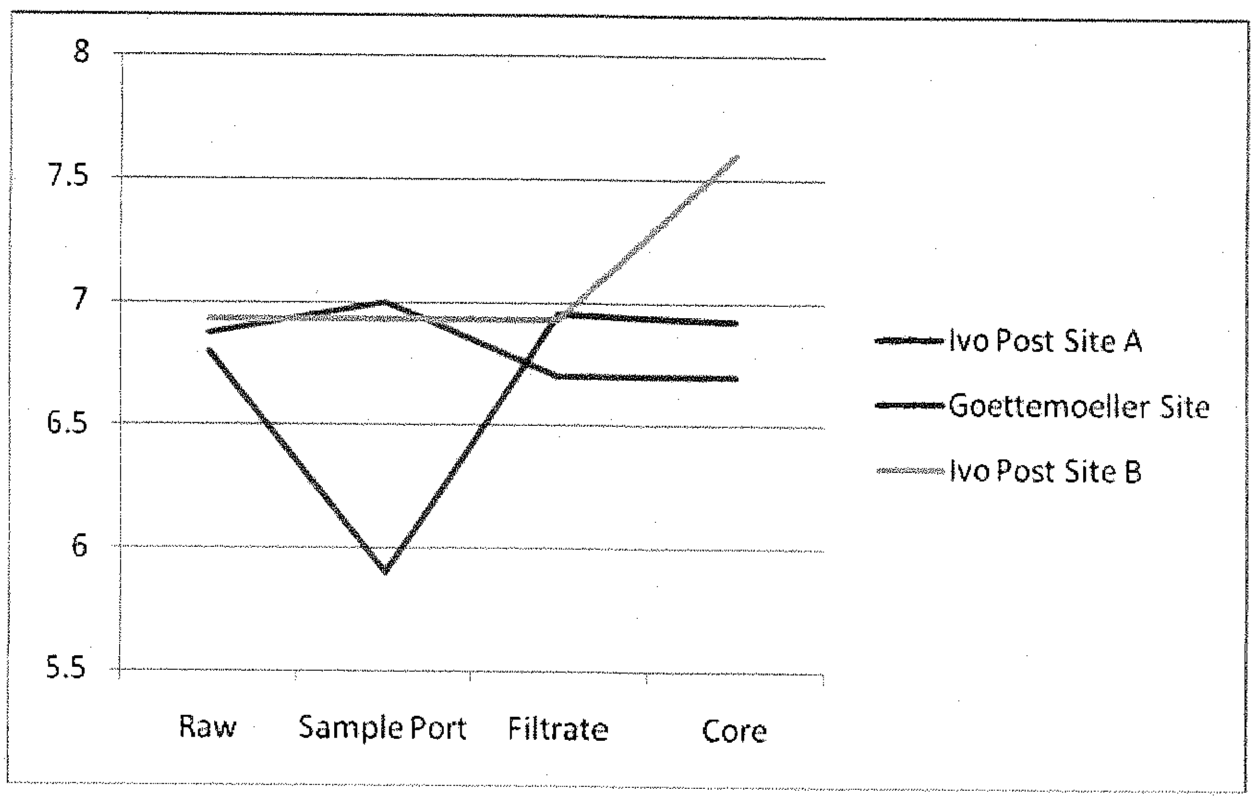
Average Nitrogen, Ammonia mg/Kg-dry



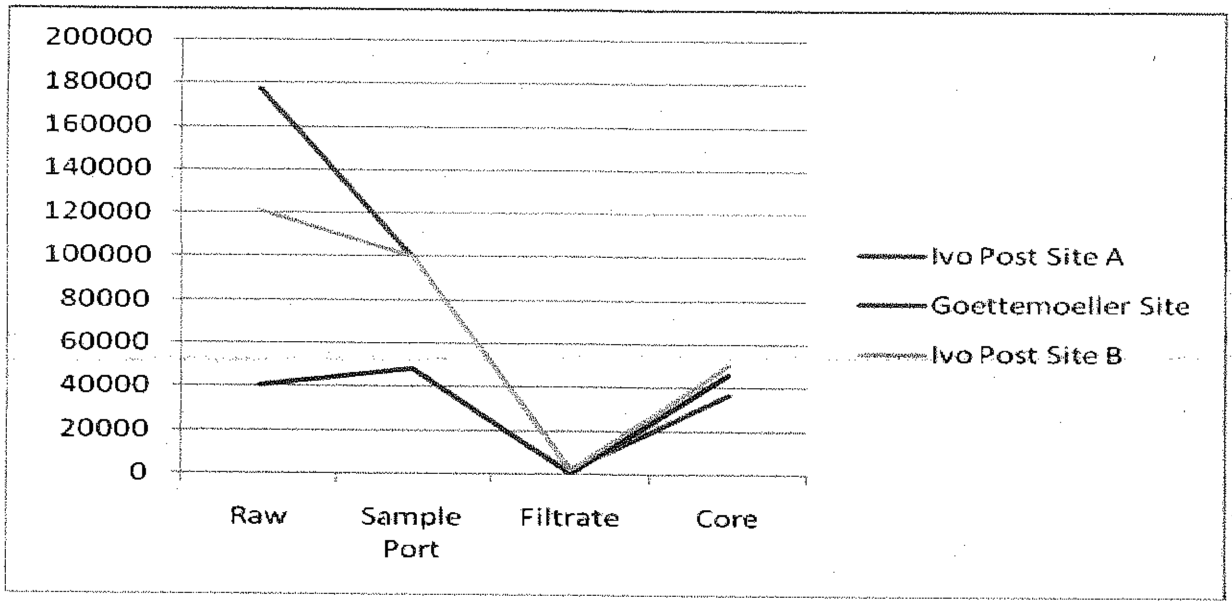
Average Phosphorus mg/Kg-dry



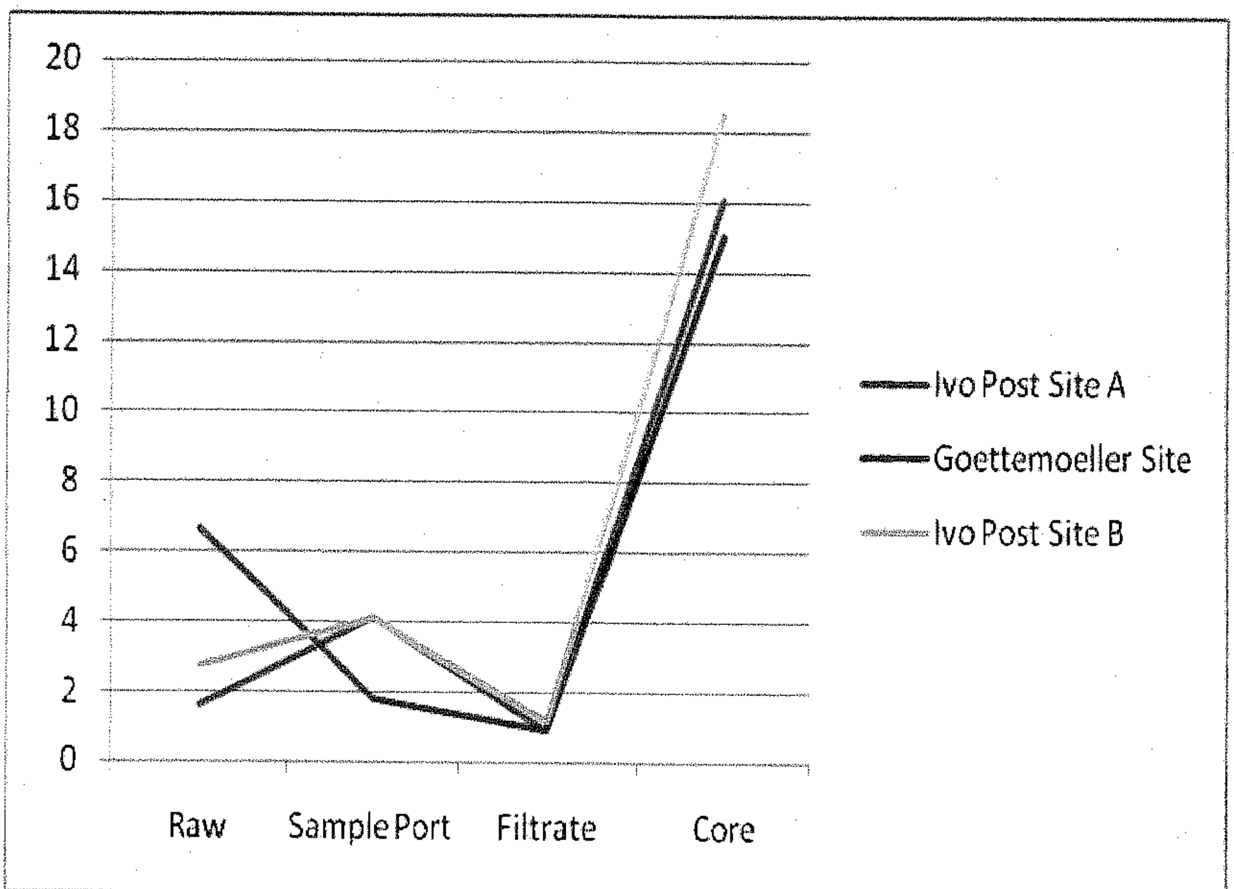
Average ph



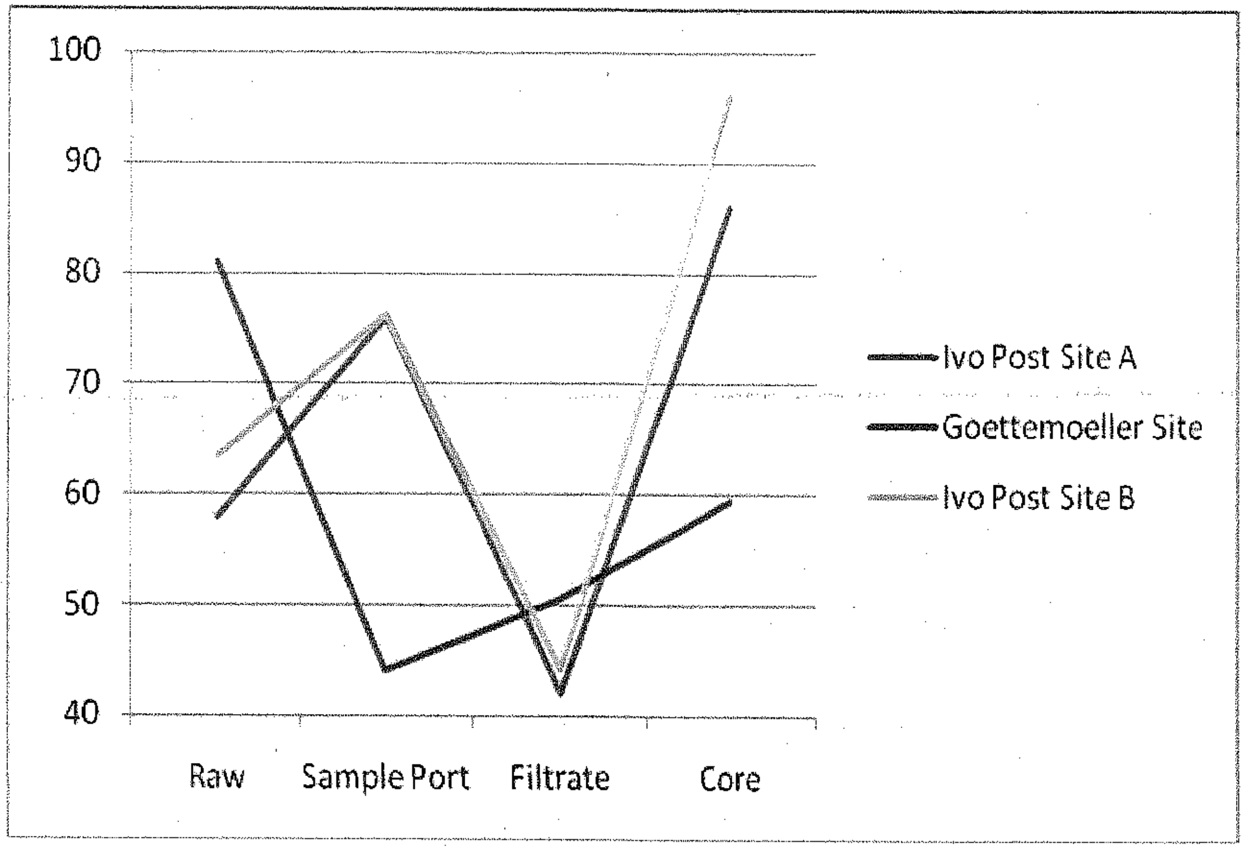
Average Nitrogen, Total Kjeldahl mg/Kg-dry



Average Total Solids Percent of sample

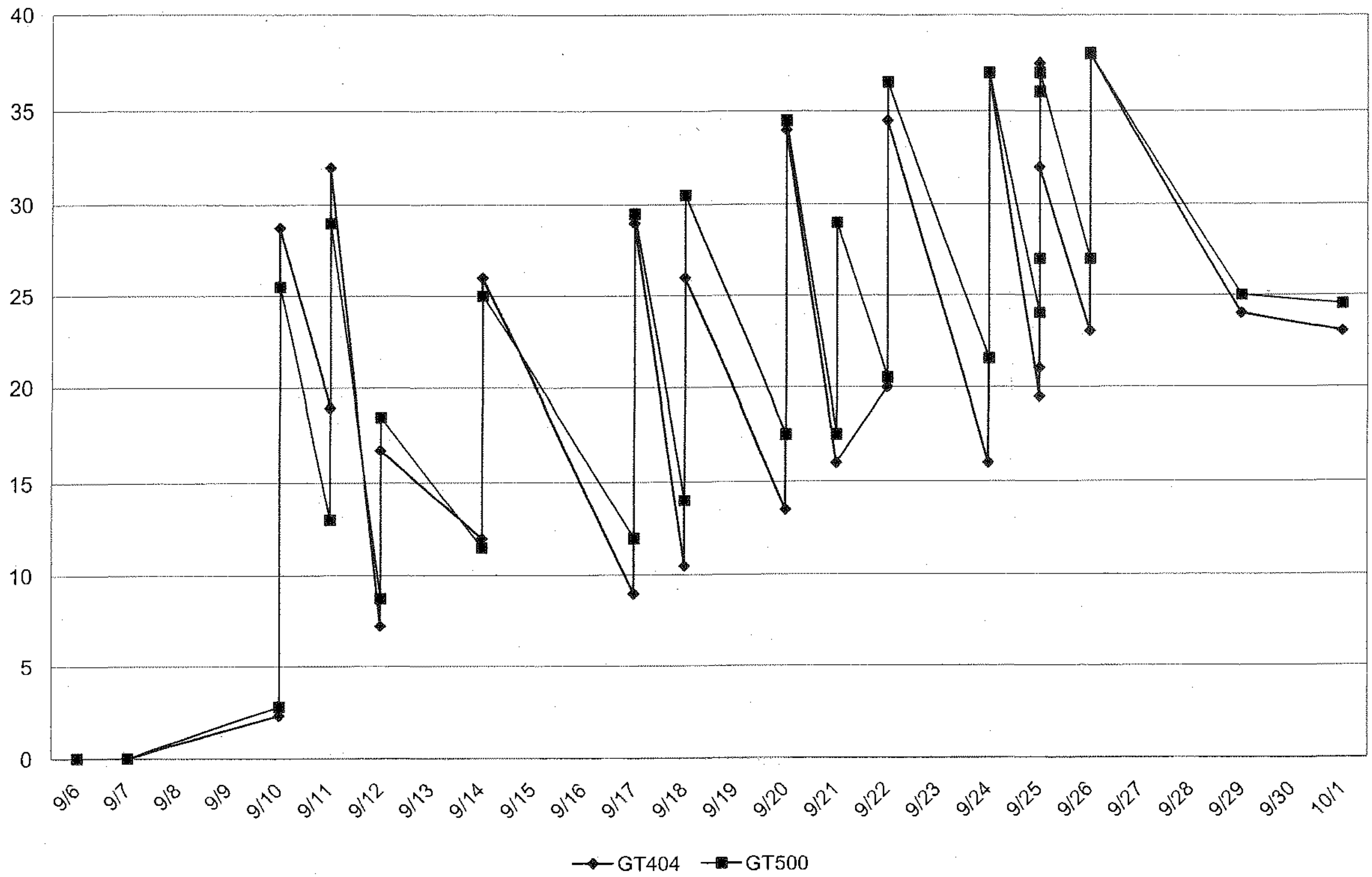


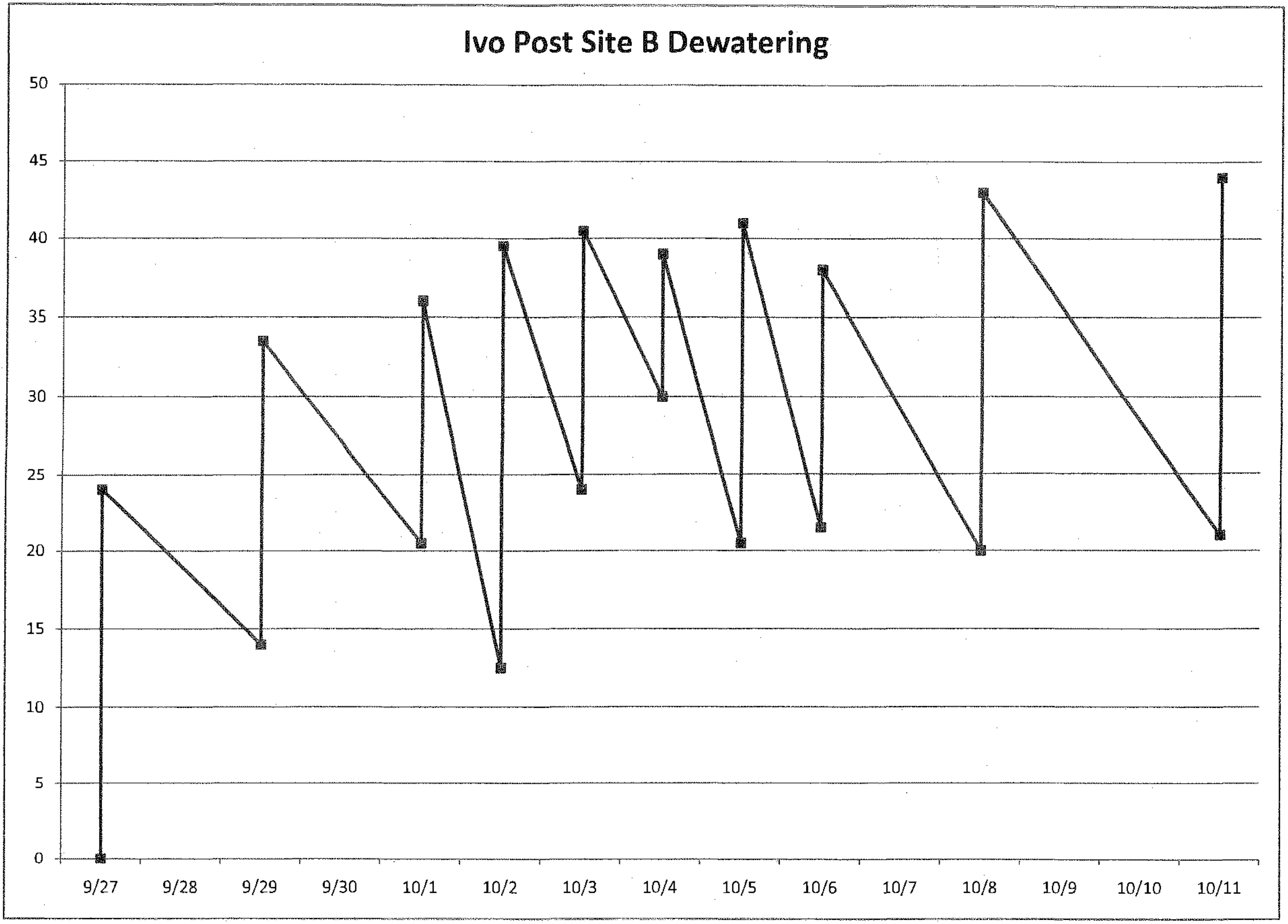
Average Volatile Solids Percent of sample



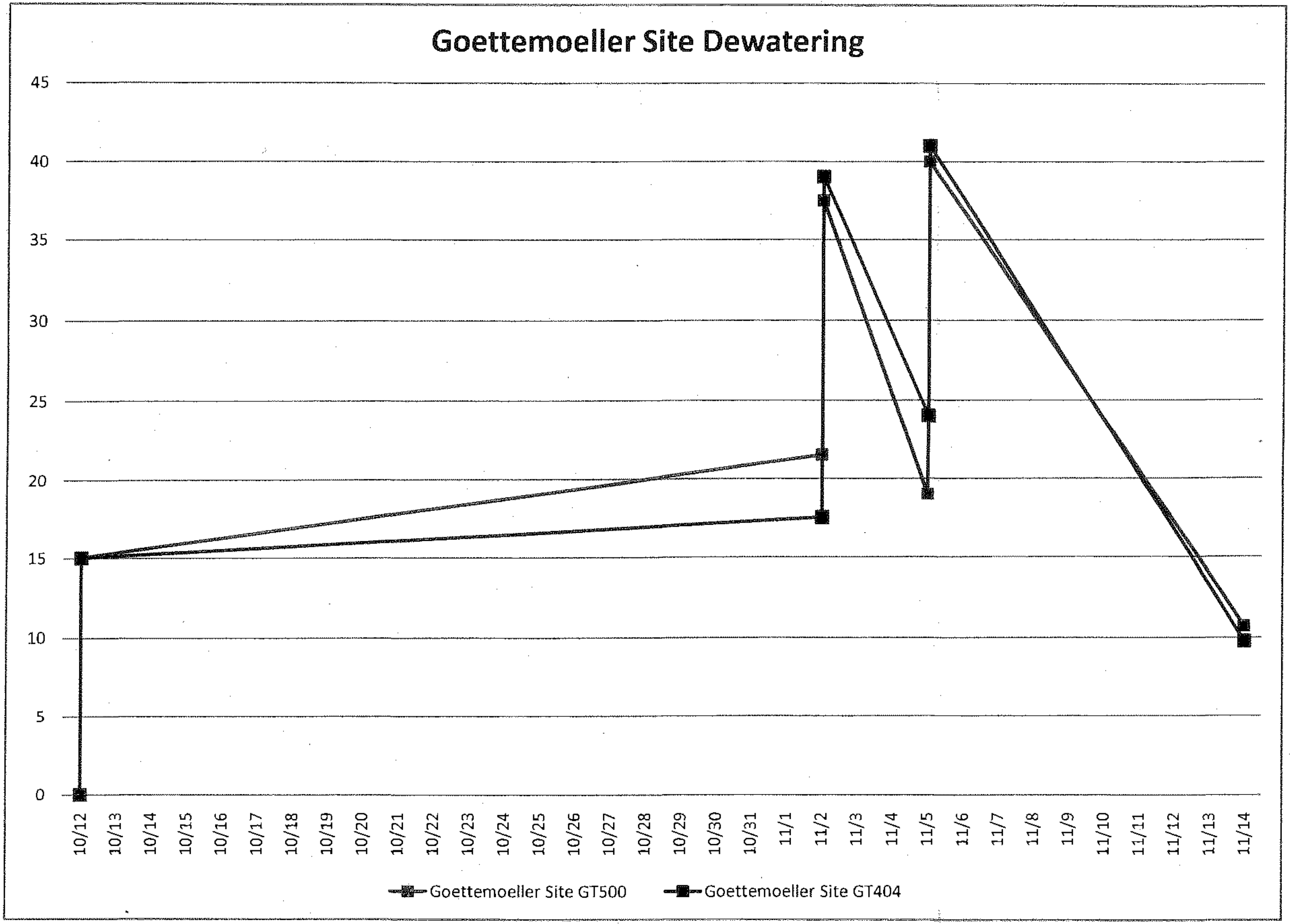
Appendix D: Dewatering Charts

Ivo Post Site A Dewatering





Ivo Post Site B Dewatering
50
45
40
35
30
25
20
15
10
5
0
9/27
9/28
9/29
9/30
10/1
10/2
10/3
10/4
10/5
10/6
10/7
10/8
10/9
10/10
10/11



Goettemoeller Site Dewatering
45
40
35
30
25
20
15
10
5
0
10/12
10/13
10/14
10/15
10/16
10/17
10/18
10/19
10/20
10/21
10/22
10/23
10/24
10/25
10/26
10/27
10/28
10/29
10/30
10/31
11/1
11/2
11/3
11/4
11/5
11/6
11/7
11/8
11/9
11/10
11/11
11/12
11/13
11/14
Goettemoeller Site GT500
Goettemoeller Site GT404

Ivo B							
Raw	Moisture % of sample	Nitrogen, Ammonia mg/Kg-dry	Phosphorus mg/Kg-dry	ph	Nitrogen, Total Kjeldahl mg/Kg-dry	Total Solids % of sample	Volatile Solids % of sample
10/1/2007	98	90,000	6,000	7	110,000	2.5	64
10/4/2007	98	120,000	19,000	6.9	150,000	1.8	57
10/8/2007	96	55,000	18,000	6.8	85,000	4.2	71
10/11/2007	98	92,000	8,800	7	140,000	2.4	62
average	**97.5**	**89,250**	**12,950**	**6.93**	**121,250**	**2.725**	**63.5**
Sample Port							
10/1/2007	96	68,000	88,000	7	160,000	3.7	91
10/4/2007	95	39,000	17,000	6.9	73,000	4.6	74
10/8/2007	96	59,000	25,000	6.8	90,000	3.6	68
10/11/2007	95	48,000	20,000	7	78,000	4.5	72
average	**95.5**	**53,500**	**37,500**	**6.93**	**100,250**	**4.1**	**76.25**
Filtrate							
10/1/2007		1,500	130	7	2,400	0.78	41
10/4/2007		1,800	120	7	2,600	1.1	43
10/8/2007		1,800	170	6.8	2,400	1.3	45
10/11/2007		1,800	170	6.9	2,600	1.5	48
average		**1,725**	**148**	**6.93**	**2,500**	**1.17**	**44.25**
Core							
10-29-017						17	
11/19/2007	81						
12/11/2007	76						
4/11/2008	80	16,000	29,000	7.6	51,000	20	96
average	**79**	**16,000**	**29,000**	**7.6**	**51,000**	**18.5**	**96**

Goettemoeller Site							
Raw Manure	Moisture % of sample	Nitrogen, Ammonia mg/Kg-dry	Phosphorus mg/Kg-dry	ph	Nitrogen, Total Kjeldahl mg/Kg-dry	Total Solids % of sample	Volatile Solids % of sample
9/6/2007	93	12,000	3,400.00	6.8	41,000	6.60	81
Effluent							
9/6/2007	96	17,000	**5,400**	6.8	59,000	4.10	70
11/5/2007	96	23,000	**4,700**	6.7	50,000	3.60	27
10/30/2007	96	24,000	**5,600**	6.7	62,000	3.60	72
10/29/2007	97	27,000	**5,200**	6.8	62,000	3.30	71
average	**96.25**	**22,750**	**5,225**	**6.75**	**58250.00**	**3.65**	**60.00**
Sample Port – port in bag							
10/29/2007	99	25,000	4,500.00	4.3	48,000	1.50	57
10/30/2007	99	27,000	3,000.00	6.8	47,000	0.84	56
11/5/2007	97	8,200	5,200.00	6.5	51,000	2.90	19
average	**98.33**	**20,067**	**4,233**	**5.9**	**48,667**	**1.75**	**44**
Filtrate GT404							
10/29/2007		430	12	6.8	660	0.82	48
10/30/2007		350	27	7.0	510	0.73	47
11/5/2007		370	24	6.9	550	0.76	53
average		**383**	**21**	**6.9**	**573**	**0.77**	**49**
Filtrate GT500							
10/29/2007		420	5	7.0	680	1.10	55
10/30/2007		380	41	6.8	660	0.86	51
11/5/2007		360	23	7.0	570	0.86	50
average		**387**	**23**	**7**	**637**	**1**	**52**
GT404 Core							
11/14/2007	90	6,900	3,400	6.4	35,000	9.90	16
11/19/2007	91						
12/14/2007	85						
5/8/2008	75	3,000	7,200	7.4	36,000	25.00	100
average	**85.25**	**4,950**	**5,300**	**6.9**	**35,500**	**17.45**	**58**
GT500 Core							
11/14/2007	96	12,000	6,900	6.4	75,000	4.00	21
11/19/2007	89						
12/14/2007	86						
5/8/2008	79	4,100	8,200	7.5	38,000	21.00	100
average	**88**	**8,050**	**7,550**	**6.95**	**56,500**	**12.50**	**61**

Ivo Post Site A							
Raw	Moisture % of sample	Nitrogen, Ammonia mg/Kg-dry	Phosphorus mg/Kg-dry	ph	Nitrogen, Total Kjeldahl mg/Kg-dry	Total Solids % of sample	Volatile Solids % of sample
9/6/2007	98	85,000	11,000	7.0	140,000	2.00	58
9/12/2007	98	110,000	30,000	6.7	140,000	2.00	60
9/20/2007	99	290,000	43,000	7.1	290,000	0.68	55
9/11/2007	98	110,000	30,000	6.7	140,000	2.00	60
average	**98.25**	**148,750**	**28,500**	**6.875**	**177,500**	**1.67**	**58**
Sample Port							
9/6/2007	96	48,000	47,000	7.0	140,000	4.20	72
9/12/2007	95	35,000	27,000	7.0	65,000	5.40	76
9/20/2007	98	110,000	54,000	7.0	130,000	1.70	78
9/11/2007	95	35,000	27,000	7.0	65,000	5.40	76
average	**96**	**57,000**	**38,750**	**7**	**100,000**	**4.18**	**76**
Filtrate GT404							
9/6/2007		1,900	110	7.0	2,500	1.00	41
9/12/2007		1,700	130	6.8	2,200	0.97	41
9/20/2007		960	92	7.0	2,300	0.99	45
9/11/2007		1,700	130	6.8	2,200	0.97	41
average		**1,565**	**116**	**6.9**	**2,300**	**0.98**	**42**
Filtrate GT500							
9/6/2007		1,900	110	5.4	2,300	0.94	41
9/12/2007		1,500	130	6.8	1,700	0.83	40
9/20/2007		1,500	97	7.0	2,000	0.97	45
9/11/2007		1,500	130	6.8	1,700	0.83	40
average		**1,600**	**117**	**6.5**	**1,925**	**0.89**	**42**
GT404 Core							
9/27/2007	88	19,000	28,000	6.5	52,000	12.00	82
10/4/2007	85	16,000	20,000	6.3	36,000	15.00	75
10/11/2007						16.00	
10/29/2007						18.00	
12/14/2007	80						
3/27/2008	80	20,000	25,000	7.3	41,000	20.00	100
average	**83.25**	**18,333**	**24,333**	**6.7**	**43,000**	**16.20**	**86**
GT500 Core							
9/27/2007	90	20,000	27,000	6.3	43,000	9.70	83
10/4/2007	83	15,000	25,000	6.4	35,000	17.00	75
10/11/2007						17.00	
10/29/2007						17.00	
12/14/2007	77						
3/27/2008	81	15,000	25,000	7.4	16,000	19.00	100
average	**82.75**	**16,667**	**25,667**	**6.7**	**31,333**	**15.94**	**86**

Appendix E: Report from Teresa Dirksen, Technician

Conclusions and Recommendations

Technician- Theresa Dirksen

Using geotextile tubes to dewater liquid manure has proven to be effective; however its economic feasibility is questionable at this time. The dewatering process was successful in dewatering both liquid hog and dairy manure. Economically, the cost of materials and labor outweigh the benefit. For example, it cost approximately $9,990 for the materials, equipment, sampling and labor to run this project at the hog operation. The total nutrients retrieved from the geotextile tubes were approximately 500 pounds of phosphorus, 320 pounds of ammonia, and 690 pounds of total kjeldahl nitrogen. Based on current market prices of commercial fertilizers, the value of the nutrients remaining in the geotextile tubes equates to approximately $750.

Based on our findings during this project, an analysis was completed to determine whether geotextile tubes could economically dewater all of the manure generated at a 1,000-head grow-to-finish hog facility. 1,000 hogs would generate approximately 580,000 gallons of manure per year. Costs to set up the manure management portion of the facility would be approximately $80,000, not including any infrastructure that would be needed. Because the geotextile tubes cannot be reused, it would cost approximately $50,000 each year for new tubes, chemicals, labor and maintenance. Using the findings of this experiment at the hog operation and current commercial fertilizer market prices, the value of the solids left in the tubes would be approximately $20,000. Therefore, it still appears that the cost outweighs the benefits of using geotextile tubes, even for a larger facility. The concept of carbon credit trading has also been discussed throughout this project. It is possible that this would be an additional source of income for the operation using geotextile tubes; however, it is unknown at this time how much additional income carbon credits would provide.

The solids removed from the geotextile tubes were of a consistency that they could be loaded into a traditional solid manure spreader and hauled to fields further away from the operation. Therefore, the geotextile tubes do allow manure nutrients to be utilized at locations that may normally not receive manure nutrients. It is also possible that the solids removed from the tubes could be brokered in a similar manner to the way poultry manure is currently brokered.

Sampling results showed that over 99% of phosphorus was retained in the geotextile tubes with the addition of flocculants and conditioners. Testing was completed on the raw manure as well as the filtrate exiting the tubes. While over 99% of phosphorus was retained in the geotextile tubes, there is still a significant concentration of phosphorus in the filtrate. Total Maximum Daily Load (TMDL) studies completed in the Grand Lake St. Marys and Wabash River watersheds outline the TMDL for phosphorus at 0.17mg/L. Results indicated an average of 126 mg/L of phosphorus in the filtrate at the hog operation. At the dairy operation, phosphorus levels in the filtrate averaged 29 mg/L. The TMDL for total nitrogen is 1.5 mg/L. Results indicated an average of 2,300 mg/L of total nitrogen in the filtrate at the hog operation, and an average of 605 mg/L of total nitrogen in the filtrate at the dairy operation. These results show that the filtrate could not be directly discharged to waters of the State without further treatment. Therefore, all effluent would need to be collected in a storage area on the farm and treated as liquid manure or irrigated on standing crops. Irrigation on standing crops would require additional infrastructure at a facility, requiring additional costs to the landowner.

Geotextile tubes can provide additional storage during the winter months when used in conjunction with another manure storage system. They would allow for additional storage when inclement weather precludes manure application to fields. The freeze/thaw cycles appeared to have no significant effect on the tubes. However, cost must be considered and the economic feasibility of using geotextile tubes on a small or large scale does not appear to be adequate at this time.

The geotextile tubes were effective in dewatering both the liquid hog manure and the liquid dairy manure. The raw dairy manure was first run through a screw press solids separator, which removed, on average, 40 percent of the solids. Flocculants and conditioners were then added to the separator effluent while pumping into the geotextile tubes. The dairy geotextile tubes exhibited some odd behaviors as compared to the hog geotextile tubes. The dairy tubes did not dewater as quickly and were not as solid. However, the sampling results showed that the majority of nutrients were retained in the tubes and the solids dewatered to about 80% moisture. Results also showed that the hog manure dewatering process peaked around 60 days of retention in the geotextile tubes. The dairy manure dewatering process appeared to peak at 180 days of retention in the geotextile tubes. This information would be valuable in considering design options of a new or existing facility that is contemplating the use of geotextile tubes to manage some or all of their manure.

Geotextile tubes have proven to be effective in dewatering liquid hog manure and liquid dairy manure that has first been run through a screw press solids separator. However, the economic feasibility is still a drawback at this time. Costs to set up and operate the geotextile tube system are significantly higher than the value of the solids remaining in the tubes at the end of the dewatering process.

Appendix F: Report from Thomas R. Rampe, P.E.

Economic Analysis of Using Geotextile Tubes to Dewater Swine Waste

By

Thomas R. Rampe, P.E.

July 15, 2008

Background

The purpose of the project was to determine if geotextile tubes could be economically used to dewater manure solids and transport the solids out of the Grand Lake Saint Marys watershed to be used as agricultural fertilizer. The analysis is based upon a producer using four geotextile tubes, each capable of holding thirty cubic yards of material. Four tubes were used in the analysis to give the producer flexibility in locating the tubes in the vicinity of the manure holding facility and in filling and emptying them.

Sources of Data in the Analysis

1. During the experimental work done at the Ivo Post farm 7500 gallons of liquid manure were dewatered in the Core B 10 cubic yard geotextile tube. The cake in the bag was 80 % moisture and the 20% solids. The solids were 2.9 % phosphorus and 5.1% nitrogen. I assumed that in an expanded operation, a cake that was 20% solids with a phosphorus content of 2.9% and 5% nitrogen could be produced.

2. Since testing was not done at the experimental site on potassium, I did not factor the value of it in the calculations.

3. Based upon recent costs, phosphorus is selling at $1.09 per pound, nitrogen at $.65 per pound, and potassium at $.45 pound. Diesel fuel is selling at $4.65 per gallon.

4. I assumed the chemicals to treat the liquid manure would cost one cent per gallon of manure pumped into the geotextile tube.

5. I assumed the cake would be used at a site 10 miles distant from the geotextile tube location and it would take one hour load the cake, haul, dump it, and return.

6. The cost of four geotextile tubes with a capacity of thirty cubic yards each was provided by the local dealer when the project was initiated.

7. The amount of labor to fill the bags, empty them, and haul the cake was estimated based upon experimental work. The hourly value of the labor was estimated based upon the producer filling and emptying the bags and a hired assistant doing the hauling.

8. Other costs included in the analysis were estimated based upon the experimental work done.

Analysis

The attached spreadsheet was prepared using the data.

The value of the dewatered manure based upon the analysis is approximately $2,600 while the cost to produce it and haul it to another location to use as fertilizer is approximately $8,600.

The major portion (70%) of the $8,600 total cost is the cost of geotextile tubes, $6,000. For the use of geotextile to be economically feasible, the cost of geotextile tubes would have to be significantly reduced. While some savings in the cost of the tubes could be achieved by using one large tube and in manufacturing, these savings would not be significant enough to affect the outcome of the analysis. If the tubes could be reused, significant reduction could be achieved in the cost of the tubes. If the bags could be reused two times, the cost in the example for the bags would drop to $2000. If they could be reused five times, the cost would drop to $1000. However, reuse of geotextile bags as bags has not been done to date and extensive product design and development would be required to produce a reusable bag.

If the percent solids could be increased in the cake, its value would be increased. For example, if the cake percent solids in the example are increased to 25%, the nutrient value in the cake would increase from approximately 25% to $3240. This increase is not nearly enough offset the costs of producing the cake. Also, achieving 20% solids in the cake consistently are probably the maximum that can be achieved by the present technology using geotextile tubes. Increasing the solid percentage would require additional research and probably more expensive chemicals or other steps that would increase the cost of producing the cake.

The analysis does not include the value of the potassium in the cake. A reasonable estimate for the value would be $500. Including that in the fertilizer value of the cake would not significantly reduce the cost benefit of using the manure cake for fertilizer.

The second largest expense in producing the cake in the example is the cost of the chemicals, estimated at $900. This is approximately 10% of the total cost in the example and 35% of the value of the cake produced. It is unlikely this cost can be reduced significantly since it is based upon the experimental results. Reducing this cost by 33% to $600 would not significantly reduce the cost to benefit ratio of using the manure cake for fertilizer. The more likely scenario is that the chemical costs will increase in the future as a result of escalating energy costs.

The third largest expense in producing the cake in the example is the cost of the transportation, estimated at $700. This is approximately 8% of the total cost in the example and 27% of the value of the cake produced. It is unlikely this cost can be reduced significantly since the figures used in the scenario were on the low side. Reducing this cost by 33% to $490 would not significantly reduce the cost to benefit ratio of using the manure cake for fertilizer. The more likely scenario is that the fuel portion of the transportation costs will increase in the future as a result of escalating energy costs.

The remaining expenses in the example are approximately 12% of the total. It is unlikely this cost can be reduced significantly since the figures used in the scenario were on the low side. If they were reduced by a third, it would not significantly reduce the cost to benefit ration of using the manure cake for fertilizer.

Conclusions:

Geotextile tubes can be used to effectively dewater swine manure and produce a cake that is 20% solids.

Based upon the above analysis, it is not cost effective to use geotextile tubes to dewater manure at this time. The cost of the bag far exceeds the value of the manure that is obtained. Unless the bags can be modified so that they can be reused efficiently several times for dewatering manure, the process will never be cost effective.

Further research on using geotextile tubes for dewatering manure should first look into the possibility of developing tubes that can be effectively reused several times. If and when that is possible, further research in other aspects of the process to reduce costs and improve process effectiveness may be warranted.

Appendix H: Budget Summary

Grant Cash Summary

Cash to Distribute - $15,500

Sources

NRCS Grant		$10,000
Lake Improvement Assoc		$1,000
Coldwater Young Farmers		$500
Marion Young Farmers		$500
WaterSolve, LLC		$2,000
AgCert Services, Inc.		$1,500
	Total	**$15,500**

Distribution

Droesch Farm Service		$2,740.29
	Hose, Valves and Fittings	
Homan, Inc.		$650.00
	Conveyer - Randy Goettemoeller Farm	
Homan, Inc.		$625.75
	Pump & Fittings	
Maria Stein Grain		$1,000.00
	Mike Broering's Time 54 hours @ $20/hour	
St. Henry Tile Co, Inc		$149.10
	Sand for berms	
Bruns Excavating, Ltd.		$195.00
	Earthwork	
St. Henry Tile Co, Inc		$52.72
	Gravel	
WaterSolve LLC		$5,571.50
	Supplies	
WaterSolve LLC		$1,610.00
	Sample Testing	
WaterSolve LLC		$230.00
	Sample Testing	
WaterSolve LLC		$345.00
	Sample Testing	
WaterSolve LLC		$920.00
	Sample Testing	
Maria Stein Grain		$269.59
	Supplies & Shipping	
Chickasaw Veterinary Center		$84.00
	Shipping	
WaterSolve LLC		$375.00
	Sample Testing	
Laura Walker		$101.12
	Shipping	
WaterSolve LLC		$15.00
	Sample Testing	
WaterSolve LLC		$460.00

	Sample Testing		
WaterSolve LLC			$505.00
	Sample Testing		
Droesch Farm Service			-$482.04
	Reimbursement		
Homan, Inc.			-$525.00
	Reimbursement		
WaterSolve LLC			-$1,481.02
	Reimbursement		
Chickasaw Veterinary Center			$10.00
	Shipping		
WaterSolve LLC			$45.00
	Sample Testing		
WaterSolve LLC			$690.00
	Sample Testing		
Homan, Inc.			$45.87
	Extension Tube & Fittings		
WaterSolve LLC			$75.00
	Sample Testing		
WaterSolve, LLC			$125.00
	Sampling Expenses		
WaterSolve, LLC			$240.00
	Sampling Expenses		
Bruns Excavating, Ltd.			$125.00
	Earthwork		
Ivo Post			$710.00
	Time & Expense		
Laura Walker			$23.20
	Shipping		
		TOTAL	**$15,500.08**

Project 4

Demonstrating the Efficacy of a Phosphorus Sorbent to Reduce Agricultural Phosphorus Transport to Protect Surface and Ground Water Quality

Final Report

CIG Project

OH-CIG-69eE34-07-82

E.A. Dayton and J.S. Undercoffer

The Ohio State University

May, 2009

Table of Contents

Abstract

Recent applications of animal manures and soils with elevated amounts of phosphorus (P) can result in surface transport of P leading to eutrophication of surface waters. This is especially true when manure is surface applied without subsequent incorporation. Addition of drinking water treatment residuals (WTR), as a P sorbent, has been identified as a potential best management practice (BMP) to reduce the solubility of manure P. A simulated rainfall study was used to demonstrate the efficacy of WTR in reducing P transport. The objectives of this study were to demonstrate reductions in P transport, and soil test P (STP), over a growing season, in field plots amended with WTR co-blended with poultry litter. Water treatment residuals were co-blended at a low (L) medium (M) and high (H) level with poultry litter to achieve final percent P saturation (P_{sat}) of the blended materials of 600% (LWTR), 200% (MWTR) and 50% (HWTR), compared to the untreated litter which had a P_{sat} of 1860% (0WTR). Co-blended treatments were surface applied, without incorporation, at 11.3 Mg ha^{-1} onto 2 m X 2m study plots and simulated rainfall was applied prior to, immediately following application and at 1 month intervals for 3 months. Immediately following co-blended WTR/poultry litter application runoff dissolved P (RDP) was reduced by 68% and 97% by MWTR and HWTR, respectively, when compared to the RDP of the 0WTR treatment (32.9 mgP L^{-1}). Three months after treatment application, the HWTR treatment retained 33% more total soil P than the 0WTR treatment suggesting a significant reduction in P transport from plots amended with co-blended HWTR treatments over a growing season. Co-blending WTR with manure to achieve a final blended $P_{sat} < 100\%$ provided excellent protection against P transport.

Introduction

Phosphorus (P) is an important plant macronutrient essential for attaining maximum crop yields. Phosphorus deficient crops exhibit stunted growth and poor grain or fruit development. For this reason it is important to maintain sufficient soil test P (STP) levels to ensure that P is not a limiting nutrient. However, when excess P is transported from soil into surface waters it can cause eutrophication, which has been identified by the USEPA as the biggest threat to surface water quality in the United States (USEPA, 2000). Eutrophication impairs water quality aesthetically and limits suitability for fishing, recreation, and as a drinking water source. The USGS (1999) reported intensively managed agriculture, primarily through livestock production, as the leading cause of P pollution.

Phosphorus can be transported from agricultural fields by surface runoff, lateral flow and leaching to subsurface drainage; however, surface runoff is thought to be the main pathway for P transport for most soils (Vadas et al., 2005). Phosphorus is transported during a runoff event as runoff dissolved P (RDP) or as runoff particulate P (RPP). The relative amounts of both RDP and RPP are controlled by the quantity of P available for transport and by site-specific considerations such as erosion potential and hydrologic conditions (Sharpley, 1995).

Transport of RPP occurs when sediment and organic matter is moved with runoff water. This process is governed by the same processes that control soil erosion. Land management practices including tillage, fertility management, vegetative cover, soil type, and slope are all important in understanding and predicting the amount of PP in runoff water. Large amounts of P can be transported to surface waters in agricultural situations attached to sediments or in P minerals (Sharpley and Smith, 1989). However as transport through erosion is mitigated, the amount of RDP moving to surface water can become an environmental concern (Sharpley et al., 1994).

The amount and solubility of P in the upper 5 cm of the soil, which interacts with rainfall and overland flow, is a primary factor in the risk of RDP transport (Tolbert et al., 2002; Paulter and Sims, 2000).

Historically, manure applications were often calibrated to satisfy crop nitrogen needs, which resulted in over application of P. Over application of P, with time, leads to high soil P levels that increase the risk of P transport to surface waters.

Regardless of soil P status, recent applications of material containing significant amounts of soluble P, such as manure, increases the risk of RDP transport (Kleinman et al., 2002; DeLaune et al., 2004). Termed "event-specific losses," heavy rains shortly after application of manure or inorganic fertilizers have the potential to transport large amounts of RDP to surface waters (Hart et al., 2004). These events can significantly contribute to water quality problems.

In response to the continued degradation of surface water, the USDA Natural Resources Conservation Service (USDA-NRCS) in each state has been mandated to choose a P-based nutrient management strategy. One of these approaches is establishing a P risk index system. Lemunyon and Gilbert (1993) first developed the P risk index in order to identify agricultural fields vulnerable to P loss. All site characteristics contributing to P loss are considered, and weighting factors are applied to account for differences in each characteristic's relative contribution to P loss. In Ohio, risk of agricultural P transport to surface water is assessed by the Ohio USDA-NRCS (2002) Phosphorus Index Assessment Procedure (Ohio P Index), within the Nitrogen and Phosphorus Risk Assessment Procedures. http://efotg.nrcs.usda.gov/references/public/OH/Nitrogen_and_Phosphorous_Risk_Assessment_Procedures.pdf.

The goal of the Ohio P Index is to asses P transport risk at the field scale to support management decisions and practices that will lead to protection of water quality. Based on the design of Lemunyon and Gilbert (1993) the index is a scoring matrix of well established source and transport factors that influence P transport. The Ohio P Index assesses P transport risk based on 9 site characteristics: soil erosion potential, runoff class, connectivity to water, soil test P, planned inorganic and organic P application rate, inorganic and organic P application method, and the presence of a filter strip. Each of these factors is weighted based on its presumed relative contribution to P transport. The sum of these values provides a field-scale Ohio P Index score.

Soil test P, based on the amount of Bray-1 or Mehlich-3 extractable P in the soil, is one of the factors evaluated by the Ohio P Index. Mehlich-3 (M3P) and Bray-1 (B1P) were developed to determine plant available soil P to predict crop response to fertilizer additions (Bray and Kurtz, 1945; Mehlich, 1984).

Recent applications of material containing significant amounts of soluble P can increase the risk of DP transport, regardless of soil P status. DeLaune et al. (2004) showed RDP concentrations of 8.8 to 33.0 mg L^{-1} one day after poultry litter surface applications ranging of 2.24 to 8.96 Mg ha^{-1}. Dayton and Basta (2005b) surface applied 8.8 Mg ha^{-1} poultry litter and reported RDP concentrations of 31.1 mg L^{-1} from simulated rainfall plots. These RDP concentrations from manure applied plots far exceed RDP values reported from high STP soil in the absence of recently applied manure (Vadas et al. 2005). STP values have little effect on RDP in the presence of recently applied manure (DeLaune et al., 2004). Because of the large potential for DP transport from surface applied manure, Ohio's P-risk index uses organic P application amounts and application methods as a P transport contributing factor.

Drinking Water Treatment Residuals

To reduce P transport from agricultural land many BMPs have been developed, mostly targeted at reducing soil erosion. These BMPs are effective in reducing the transport of PP, however, they are not as effective in reducing the loss of DP (Daniel et al., 1998). New best management strategies need to be developed to control the risk of RDP transport. One promising development in recent years is the beneficial use of drinking water treatment residuals (WTR).

Drinking water treatment residuals (WTR) are the by-product of a source a water coagulation process drinking water treatment plants often use. The coagulation process uses salts of Al and Fe (typically alum and ferric chloride, respectively) to flocculate particles, clarifying the source water. The resulting WTR is a sludge that settles out and contains a mixture of source water sediment and organic matter, as well as, reaction products coagulation, amorphous Al or Fe hydroxides. Currently, many facilities dispose of these materials in landfills. Beneficial use of WTR could provide financial benefits to utilities and municipalities, save landfill space, and provide an environmental benefit to communities by reducing nonpoint source agricultural P pollution.

Early WTR research showed that WTR has the ability to bind and reduce the solubility of phosphorus (Bugbee and Frink, 1985; Elliott and Dempsey, 1991; Peters and Basta, 1996; Dayton and Basta, 2001). Amorphous hydroxides of Al or Fe are the WTR component responsible for P adsorption (Dayton and Basta, 2003). Aluminum and iron hydroxides form an inner-sphere complex with orthophosphate in soil. The Al_{ox}-P bond that is formed is strong, not readily desorbable, and stable over time and during changes in environmental conditions (Agyin-Birikorang and O'Connor, 2007; Dayton and Basta, 2005b). Dayton and Basta (2005a) described the relationship the extractable Al content of a WTR and its P sorption capacity.

These materials have been shown to decrease the solubility of phosphorus in soil reducing STP and the risk of RDP tranport from high STP soils (Codling et al., 2000; Novak and Watts, 2005b; Peters and Basta, 1996; Dayton and Basta, 2005b; Haustien et al., 2000; Agyin-Birikorang et al., 2007). Drinking water treatment residuals have also been shown to reduce the solubility of P in manure and biosolids reducing the risk of DP tranport from surface applications of manure or biosolids (Ippolito et al., 1999; Gallimore et al., 1999; Elliott et al., 2002; Dayton and Basta, 2005b; Makris et al., 2005; Codling et al., 2000; Dao et al., 2001; Oladeji et al., 2007). To ensure the proper implementation and management of this potential BMP it is necessary to evaluate P transport, and changes to the factors that influence P transport, in the presence of WTR.

Co-Blended WTR and Manure as a Best Management Practice

Blending manure with Drinking Water Treatment Residuals (WTR) has been suggested as a way to mediate the water quality risk associated with surface applications of manure. Multiple laboratory studies have analyzed the reductions of soluble P in manure or biosolids due to co-blending with WTR (Ippolito et al., 1999; Codling et al., 2000; Dayton and Basta, 2005b; Makris et al., 2005; Dao et al., 2001).

Reductions in manure P solubility due to additions of WTR have been shown to reduce RDP transport from surface applications of manure (Gallimore et al., 1999; Elliott et al., 2002; Oladeji et al., 2007)

Objectives

The objectives of this study are to:

1. Demonstrate the effectiveness of WTR co-blended with poultry litter, as a BMP, to reduce STP, P solubility and P transport from field plots receiving surface applied manure
2. Demonstrate the WTR co-blended with poultry litter BMP efficacy to reduce P transport over a growing season.

The objectives were accomplished using field simulated rainfall studies.

Materials and Methods

WTR Collection and Characterization

Drinking water treatment residuals were collected from the Celina Drinking Water Treatment Plant in Celina, Ohio. The Celina Drinking Water Treatment plant uses water from Grand Lake St. Mary's (GLSM) as its source water. They use aluminum salts for coagulation to remove suspended sediments and organic matter from the source water. The WTR was collected, homogenized in a cement mixer, air dried, crushed and sieved (2 mm) before analysis and co-blending with poultry litter. The Al, Fe and P content of the material was analyzed using an acid ammonium oxalate extraction (100:1 solution to WTR) (McKeague and Day, 1993; Dayton and Basta, 2005a; Dayton and Basta, 2001).

Field Plots

Small field plots and simulated rainfall was used to generate surface runoff to demonstrate the ability of WTR co-blended with poultry litter to reduce P transport and soil test P. The field site was located in Celina, Ohio in the GLSM watershed. Plots measuring 2 x 2 m were established in an alfalfa field on a Glynwood silt loam soil (fine, illitic, mesic Aquic Hapludalfs) with a 4 percent slope. Plot establishment and rainfall simulation followed protocol established by the National Phosphorus Research Project (National Phosphorus Research Protocol, 2007).

Each plot received a 4.5 kg (11.3 Mg ha^{-1}) application of air dried poultry litter. Total P content of poultry litter was determined by digesting manure according to EPA Method 3050B (U.S. EPA, 1996). Soluble P in manure was determined by a 1g: 200 mL deionized water extraction (Wolf et al., 2005). The poultry litter was applied to all plots at the same level of 4.5 kg (11.3 Mg ha^{-1}), which was co-blended with one of four amounts of WTR: High WTR (HWTR) 84 g kg^{-1} or 945 kg WTR ha^{-1}, Medium WTR (MWTR) 21 g WTR kg^{-1} or 236 kg WTR ha^{-1}, Low WTR (LWTR) 7 g WTR kg^{-1} or 79 kg WTR ha^{-1}, and a control treatment of 0 g WTR kg^{-1} manure (0WTR). Manure and WTR treatments were blended in a cement mixer in batches 2 wk prior to application to ensure homogeneity of treatments. Each of the four treatment levels were replicated 5 times, for a total of 20 plots.

Simulated Rainfall

Simulated rainfall was supplied using a single Teejet ½ HHSS50WSQ nozzle mounted 3 m above the soil surface on a rainfall simulator following the design of Miller (1987). The rainfall simulator was calibrated using methods outlined by Humprey et al. (2002) and met recommended criteria for rainfall distribution with a 93% coefficient of uniformity, and rainfall intensity of 60 mm hr^{-1}. This rainfall intensity, maintained over a one hour duration, occurs on average once every 10 years in Ohio. During rainfall simulation temporary metal borders were installed around the perimeter of the plot to isolate runoff and channel it to a PVC pipe which led downslope to a large collection vessel. All runoff was collected for 30 minutes after it commenced. A 250 mL composite sample of homogenized runoff was collected and a 20 mL subsample was 0.45 μm filtered and acidified (one drop concentrated HCl per 10 mL sample). Runoff dissolved P (RDP) was determined from the filtered sample using inductively coupled plasma atomic emission spectroscopy (ICP). Runoff total P (RTP) was determined by digesting 50 mL of homogenized runoff water with 0.5 g potassium persulfate and 1 mL of concentrated sulfuric acid in a Mars Xpress microwave at 170 C° for 30 min (Pote and Daniels, 2000). Sodium pyrophosphate check standards (1 mg P L^{-1}) were also digested with satisfactory P recovery (99%).

Simulated rainfall was performed on each plot 5 times: Time 0 (T0) before any treatment application to evaluate background runoff and field variability in November 2007, Time 1 (T1) immediately after treatment application in June 2008, and three more times at intervals of approximately one month, mid-July (T2), mid-August (T3), and mid-September 2008 (T4). Simulated rainfall took place within a week after crop harvest to ensure consistent crop height (approximately 15 cm) with the exception of the initial rainfall which took place in November, 2007 when no crop harvest was anticipated.

Composite samples of the surface soil (5 cm depth), taken from ten locations within each plot, were collected after each rainfall simulation. Samples were oven dried (60 C°) and sieved (< 2mm). Soil P status was evaluated using multiple soil extractions. Mehlich 3-extractable P (M3P) and Bray 1-extractable P (B1P) were analyzed with 1 g of soil: 10 mL of corresponding extraction solution shaken for 5 minutes on a rotating shaker (150 evolutions min^{-1}) and filtered (<0.45 μm) (Bray and Kurtz, 1945; Mehlich, 1984). Soil % P saturation (P_{sat}) was measured with a 0.25 g: 25 mL acid ammonium oxalate extraction shaken for 4 hours on an oscillating shaker and filtered (<0.45 μm) (McKeague and Day, 1993; Dayton and Basta, 2005). Soluble P was evaluated using a 2g soil: 20 mL deionized water extraction (WEP) shaken for 1 hour, filtered (<0.45 μm) and acidified (one drop concentrated HCl per 10 ml of sample; Olsen and Sommers, 1982).

All extracts were analyzed by ICP according to USEPA methods 6010C on a Varian Vista-MPX ICP-OES (Varian Inc., Walnut Creek, CA). Data QA/QC included analysis of an intra-laboratory established control sample, initial calibration verification, initial calibration blank, continuing calibration verification every ten samples, continuing calibration blank every ten samples, and a low limit of quantitation verification. All checks were within the quality control limits set in USEPA ILM04.0b.

Statistical Analysis

All data were Log_{10} transformed before analysis to control for unequal variances. After the transformation all tests complied with Levene's test for unequal variances ($\alpha > 0.10$). Outliers within groups were determined using Dixon's test ($\alpha \leq 0.10$) for outliers which determines if the minimum and maximum values fall outside of the calculated range (Sheskin, 1997). Differences in soil test and runoff results were assessed using a one-way ANOVA, with Fisher's least significant difference (LSD) pair-wise comparisons for means separation. Analysis was conducted using SAS, version 9.1 (SAS Institute Inc., 2002). Significant differences are assigned at $\alpha \leq 0.10$. Percent change is calculated as the difference between a measured value and of the control (0WTR) and is only shown if the difference is significant.

Results

Characterization of Background Soil and Materials Used

Properties of the WTR, poultry litter, and Glynwood soil at the field site are summarized in Table 1. The WTR had an oxalate extractable Al (Al_{ox}) content of 115 g kg^{-1}, which is within the range (13.9-165 g kg^{-1}) for 18 Al based WTRs reported by Dayton and Basta (2005a), representing an approximately 100 fold increase in reactive Al as compared to the Glynwood soil at the field site and more than 500 times more than the poultry litter. Oxalate extractable P (P_{ox}) content of the poultry litter (8.62 g kg^{-1}) was 97% of the total P (8.89 g kg^{-1}) which was approximately 5 and 14 times greater than the WTR and Glynwood soil, respectively (Table 1). Oxalate extractable Fe (Fe_{ox}) content was highest in the Glynwood soil (Table 1). All materials have near, to slightly above, neutral pH (Table 1).

Field Runoff Study

The T0 sampling, before any treatment application, indicates minimal variability of soil test P and runoff dissolved P (RDP) at the field site. All soil extractions and RDP were not significantly different between plots at T0. At T0 mean RDP for all plots was 0.148 mg L^{-1} (Table 2). Mean Bray-1 Extractable P (B1P), Mehlich-3 Extractable P (M3P), and Water Extractable P (WEP) values were 120, 191, and 15.9 mg kg^{-1}, respectively (Table 2). Initial soil P_{ox} and Al_{ox} had mean values of 622 and 1112 mg kg^{-1}, respectively (Table 2). Mean percent P saturation (P_{sat}) was 18.8% (Table 2).

Results of the co-blended poultry litter/WTR treatments on RDP are summarized in Table 2 and Figure 1A. At T1 the mean RDP was 32.9, 33.7, 10.5, and 1.00 mg L^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The RDP of HWTR was reduced 97% compared to 0WTR and was significantly lower than all other treatments (Figure 1A). The MWTR RDP was reduced by 68% from the 0WTR treatment and was significantly lower than the 0WTR and LWTR treatments (Figure 1A). The LWTR RDP was not significantly different than the 0WTR at T1. At T2 the RDP was 0.886, 0.803, 0.716, and 0.386 mg L^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The RDP from the HWTR treatments was significantly lower than all other treatments and was 56% lower than the 0WTR treatments (Figure 1A). The RDP from the MWTR and LWTR treatments were not significantly different than the 0WTR treatment or each other at T2. At T3 RDP ranged from 0.262 to 0.392 mg L^{-1}, and RDP ranged from 0.726 to 0.831 mg L^{-1} at T4 (Table 2). There were no significant effects of the WTR treatment at T3 or T4.

Results of the co-blended poultry litter/WTR treatments on Runoff Total P (RTP) are summarized in Table 2 and Figure 1.1B. At T1 the mean RTP was 35.4, 41.0, 19.9, and 12.7 mg L^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The RTP from the HWTR and MWTR treatments were significantly lower than the 0WTR treatment with 64% and 44% reductions, respectively, though these reductions were not significantly different from each other (Figure 1B). The RTP from the LWTR treatment was not significantly different than 0WTR at T1. At T2 the RTP was 2.13, 1.93, 1.70, and 1.30 mg L^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The RTP from the HWTR and MWTR treatments were significantly lower than the 0WTR treatments with 39% and 20% reductions, respectively, though these reductions were not significantly different from each other (Figure 1B). The RTP of the LWTR treatment was not significantly different than any other treatment at T2. At T3 RTP ranged from 1.63 to 3.50 mg L^{-1}, and RTP ranged from 2.10 to 2.92 mg L^{-1} at T4 (Table 2). There were no significant effects due to the WTR treatment at T3 or T4.

Results of the co-blended poultry litter/WTR treatments on B1P extractable P are summarized in Table 2 and Figure 2A. At T1 the mean B1P was 242, 192, 214, and 163 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The B1P of the HWTR and LWTR treatments were significantly lower than the 0WTR treatments with 33% and 21% reduetions, respectively (Figure 2A). The B1P of the MWTR treatment was not significantly different than the 0WTR or the LWTR treatments at T1. At T2 the B1P was 227, 236, 221, and 167 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The B1P of the HWTR treatment was significantly lower than all other treatments with a 27% reduction from the 0WTR treatment (Figure 2A). There was no significant difference in B1P among the other treatments at T2. At T3 the B1P was 156, 185, 145, and 128 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The B1P of the HWTR treatment was significantly lower than all other treatments with an 18% reduction from the 0WTR treatment (Figure 2A). The B1P of the LWTR treatment was significantly higher than all other treatments with a 19% increase from the 0WTR treatment (Figure 2A). The B1P of the MWTR treatment was not significantly different than the control at T3. At T4 B1P ranged from 131 to 176 mg kg^{-1} (Table 1.2). There were no significant differences in B1P due to the WTR treatment at T4.

Results of the co-blended poultry litter/WTR treatments on M3P are summarized in Table 2 and Figure 2B. At T1 the mean M3P was 593, 380, 490, and 306 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The M3P of the HWTR treatment was significantly lower than the 0WTR and MWTR treatments with a 48% reduction from the 0WTR treatment (Figure 2B). The M3P of the MWTR and LWTR treatments were not significantly different than the 0WTR treatment or each other at T1. At T2 the M3P was 342, 465, 419, and 314 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). There were no significant reductions in M3P at T2. The M3P of the MWTR and LWTR treatments were significantly higher than the 0WTR treatments with 36% and 22% increases, respectively, though they were not significantly different from each other (Figure 2B). The M3P of the HWTR treatment was not significantly different than the 0WTR treatment at T2. At T3 the M3P was 358, 441, 348, and 280 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The M3P of the HWTR treatment was significantly lower than all other treatments with a 22% reduction from the 0WTR treatment (Figure 2B). The M3P of the LWTR treatment was also significantly different than all other treatments with a 33% increase from the 0WTR treatment (Figure 2B). The M3P of the MWTR treatment was not significantly different than the 0WTR treatment at T3. At T4 the M3P was 339, 398, 295, and

212 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The M3P of the HWTR treatment was significantly different than all other treatments with a 38% reduction from the 0WTR treatment (Figure 2B). The M3P of the MWTR and LWTR treatments were not significantly different than the 0WTR treatment at T4, though the MWTR treatment was significantly lower than LWTR.

Results of the co-blended poultry litter/WTR treatments on WEP are summarized in Table 2 and Figure 2C. At T1 the mean WEP was 51.7, 26.6, 29.6, and 21.1 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The WEP of the HWTR, MWTR, and LWTR plots were all significantly lower than the control plots with 59%, 43%, and 49% reductions, respectively, though the LWTR, MWTR and HWTR plots were not significantly different from each other (Figure 2C). At T2 the WEP was 33.6, 29.3, 24.9, and 18.4 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The WEP of the HWTR treatment was significantly different than all other plots with a 45% reduction from the 0WTR treatment (Figure 2C). The WEP of the MWTR and LWTR treatments were not significantly different than 0WTR or each other at T2. At T3 the WEP was 23.6, 25.0, 21.4, and 14.5 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The WEP of the HWTR treatment was significantly lower than all other treatments with a 39% reduction from the 0WTR treatment (Figure 2C). The WEP of the MWTR and LWTR treatments were not significantly different than the 0WTR or each other at T3. At T4 the WEP was 27.7, 27.8, 19.9, and 15.5 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The WEP of the HWTR and MWTR plots were significantly lower than the 0WTR and LWTR treatments with 44% and 28% reductions, respectively, though they were not significantly different from each other (Figure 2C). The WEP of the LWTR plots were not significantly different than the control at T4.

Results of the co-blended poultry litter/WTR treatments on P_{ox} are summarized in Table 2 and Figure 3A. At T1 the mean P_{ox} was 1302, 996, 1271, and 1565 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The P_{ox} of the LWTR treatment was significantly lower than all other treatments with a 24% reduction from the 0WTR treatment (Figure 3A). The MWTR and HWTR treatments did not significantly differ from the 0WTR treatment or each other at T1. At T2 the P_{ox} ranged from 950 to 1170 mg kg^{-1} (Table 2). There were no significant differences in P_{ox} due to the WTR treatment at T2. At T3 the P_{ox} was 893, 1045, 1003, and 1196 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The P_{ox} of the HWTR treatment was significantly higher than the 0WTR and MWTR treatments, but not significantly different than the LWTR treatment, with an increase of 34% from the 0WTR treatment (Figure 3A). The P_{ox} of the MWTR and LWTR treatments were not significantly different than the 0WTR treatments or each other at T3. At T4 the P_{ox} was 846, 976, 758, and 1303 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The P_{ox} of the HWTR treatment was significantly higher than 0WTR and MWTR treatments with an increase of 54% from the 0WTR treatment (Figure 3A). The P_{ox} of the MWTR and LWTR treatments were not significantly different than the 0WTR treatment or each other at T4.

Results of the co-blended poultry litter/WTR treatments on Al_{ox} are summarized in Table 2 and Figure 3B. At T1 the mean Al_{ox} was 976, 1221, 1618, and 4505 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The Al_{ox} of the HWTR, MWTR, and LWTR treatments were all significantly higher than the 0WTR treatment and significantly different from each other with 362%, 65%, and 25% increases from the 0WTR treatment, respectively (Figure 3B). At T2 the Al_{ox} was 1180, 1287, 1576, and 2853 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The Al_{ox} of the HWTR treatment was significantly higher than all other treatments with a 142% increase from the 0WTR treatment (Figure 3B). The MWTR treatment was significantly higher than the 0WTR and LWTR plots with a 34% increase from the 0WTR treatment (Figure 3B). The Al_{ox} of the LWTR treatment was not significantly different than the 0WTR treatment at T2. At T3 the Al_{ox} was 1041, 1184, 1365, and 2789 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The Al_{ox} of the HWTR treatment was significantly higher than all other treatments with an increase from the 0WTR of 168% (Figure 3B). The MWTR treatment was significantly higher than the 0WTR treatment with a 31% increase, though not significantly different from the LWTR treatment. The Al_{ox} of the LWTR treatment was not significantly different than the 0WTR treatment at T3. At T4 the Al_{ox} was 1006, 1098, 1254, and

3271 mg kg^{-1} for the control, low, medium, and high WTR treatments, respectively (Table 2). The Al_{ox} of the HWTR treatment was significantly higher than all other treatments with an increase of 225% from the 0WTR treatment (Figure 3A). The Al_{ox} of the MWTR and LWTR treatments were not significantly different than the 0WTR treatment or each other at T4.

Results of the co-blended poultry litter/WTR treatments on P_{sat} are summarized in Table 2 and Figure 3C. At T1 the mean P_{sat} was 44.7%, 29.7%, 32.8%, and 22.3% for the control, low, medium, and high WTR treatments, respectively (Table 2). The P_{sat} of the HWTR, MWTR and LWTR treatments were all significantly lower than the 0WTR treatment with 50%, 27%, and 34% reductions, respectively, though the LWTR and MWTR treatments were not significantly different from each other (Figure 3C). At T2 the P_{sat} ranged from 21.8% to 30.0% (Table 2). There was no significant difference in P_{sat} due to the WTR treatment at T2. At T3 the P_{sat} was 29.9%, 34.4%, 29.8%, and 23.5% for the control, low, medium, and high WTR treatments, respectively (Table 2). The P_{sat} of the HWTR treatment was significantly lower than all other treatments with a 22% reduction from the 0WTR treatment (Figure 3C). The P_{sat} of the MWTR and LWTR treatments were not significantly different from the 0WTR treatment at T3 though the MWTR treatment was significantly lower than the LWTR treatment (Figure 3C). At T4 the P_{sat} ranged from 23.5% to 31.1% (Table 2). There was no significant difference in P_{sat} due to the WTR treatment at T4.

Discussion

Co-blending WTR with manure greatly reduced the transport of runoff dissolved phosphorus (RDP) and runoff total phosphorus (RTP) in surface runoff immediately after manure surface application when the risk of P transport is greatest. Co-blending WTR as a best management strategy provided significant water quality protection at T1 where the HWTR and the MWTR treatment reduced RDP and RTP by 97% and 64%, respectively (Figure 1). These are substantial reductions, and at WTR application amounts of less that 10%, co-blending WTR with manure could be a useful tool for protection of water quality from P transport. Runoff total phosphorus was substantially reduced by the WTR co-blended treatment although not as much as RDP. This is most likely due to the physical transport of sediment bound-P in the runoff water.

Previous work has suggested that WTR bound P is not bioavailable and should not adversely affect water quality (Agyin-Birikorang et al., 2007), however in this research data the sample was digested which will release P from WTR.

The RDP and RTP reductions in this study are larger than previous co-blending/simulated rainfall research (Gallimore et al. 1999). Gallimore et al. (1999) reported 42.7% reduction of RTP and similar percent reduction of RDP from a 44.8 Mg ha^{-1} application of WTR compared to the 64% reduction of RTP and 97% reduction of RDP from a 0.95 Mg ha^{-1} application amount of WTR in this study. Amounts of poultry litter P applied between these 2 studies were similar, 104 kg P ha^{-1} in Gallimore et al. (1999) and 101 kg P ha^{-1} in this study. Two potential reasons for the higher RDP reductions in this study are differences in WTR Al_{ox} content and co-blending methods between the two studies. First, the WTR used in this experiment contained more than two times the Al_{ox} than the one used in the Gallimore et al. (1999) study. The differences in WTR application amounts are not as drastic when put on an Al_{ox} basis, the component of WTR responsible for P sorption (Dayton et al., 2003). In this study, HWTR was blended to achieve a 2:1 Al_{ox} to P molar ratio while Gallimore et al. (1999) was blended at an approximate molar ratio of 24:1. The Al_{ox} to P ratio was selected for comparison because this ratio has been shown to be strongly related to manure P solubility and DP transport in previous WTR co-blending studies (Ippolito et al., 1999; Elliott et al., 2002; Makris et al., 2005). Secondly, application methods between the two studies are not the same. In Gallimore et al. (1999) poultry litter and WTR were not co-blended prior to land application. Poultry litter was applied to plots and WTR was broadcast over the litter application. In our study, the WTR and poultry litter was mixed two weeks prior to land application. These results suggest that the increased contact of WTR and manure P prior to field application may increase the effectiveness of WTR co-blending. This is beneficial because less WTR may be necessary to achieve water quality benefits immediately following a surface application of manure when WTR is co-blended with the manure prior to land application. Also, timing the availability and spreading of WTR with the application of manure would not be necessary as the WTR could be directly loaded into manure storage structures where loading, unloading, and agitation equipment could provide thorough WTR mixing. This could make WTR co-blending as a BMP more convenient for both the municipality and the producer.

Correct calibration of WTR co-blending is necessary to achieve the desired water quality benefits. If too little WTR is co-blended with manure, significant amounts of P transport can still occur as evidenced by LWTR at T1 in this study (Figure 1). Co-blending more than enough WTR necessary to protect water quality can potentially waste WTR without additional water quality benefit (Ippolito et al., 1999). WTR co-blending amounts in this study were selected based on projected final P_{sat} of the blended material. The HWTR, corresponding to 50% P_{sat}, provided the greatest water quality benefit (Figure 1). This supports previous research which has shown relatively low manure P solubility and DP transport when WTR co-blended materials achieve a molar excess of Al_{ox} relative to P_{ox} ($P_{sat} < 100\%$) when compared to WTR co-blended materials that have a molar excess of P_{ox} relative to Al_{ox} ($P_{sat} > 100\%$) (Elliott et al., 2002; Makris et al., 2005). Using the Al_{ox}:P_{ox} molar ratio, or P_{sat}, could provide a simple method of WTR co-blending calibration based on a calculation, rather than relying on empirical relationships between manure P solubility and WTR co-blending which change depending on WTR and manure properties (Dayton and Basta, 2005b).

Runoff dissolved phosphorus from the 0WTR treatment at T1 was similar to values reported in simulated rainfall research which measured P transport from recently applied manure (DeLaune et al. 2004; Dayton and Basta, 2005b). Over time the effect of the treatment and the manure application on RDP and RTP was diminished (Figure 1). Phosphorus transport from all plots was significantly less for sampling events T2, T3, and T4 (Figure 1). The reduction in RDP with time is most likely due to loss of P in surface runoff and sorption of soluble P as it is moved into the surface soil or natural attenuation of the applied P. This process was likely accelerated by above normal rainfall events that took place between T1 and T2 at the field site. Significant loss of manure P from the 0WTR treatment is evidenced by reductions in P_{ox} on the 0WTR treatments between T1 and T2 (Figure 3A). This demonstrates the importance of timing manure applications when runoff producing rainfall events are least likely. However, even immediately after manure application, when the risk of P transport is the greatest, WTR co-blending reduced P transport. After the impact of the manure application on P transport was diminished through natural attenuation, the effect of WTR on P transport was no longer evident. However, examining the amounts and solubility of P between the 0WTR and HWTR treatments demonstrate a continued treatment effect throughout the duration of the experiment.

The 0WTR treatment shows a large increase in P solubility immediately after manure application (Figure 2C). P solubility of the 0WTR treatment decreases with time supporting the natural attenuation of manure P. The WTR treatments greatly reduced P solubility along a general trend of decreasing P solubility with increase amounts of blended WTR, following previously established trends (Codling et al., 2000; Elliott et al, 2002). Soluble P remains fairly constant over time for plots treated with WTR when compared to the 0WTR treatment. This demonstrates the stability of WTR bound P over a 3 month period, although the stability of WTR bound P has been demonstrated to be stable for as long as 7.5 years (Agyin-Birikorang et al, 2007). This is consistent with the long-term stability of Al-P sorbed complex in the Al_{ox} fraction of the WTR. At T4, soluble P (WEP) from the HWTR treatment was 44% less than the 0WTR despite the HWTR treatment containing 33% more total P (Figure 2C).

P_{sat} has been shown to be a robust measure of the risk for P transport working across a wide range of soil with different P retention properties (Vadas et al., 2005; Hooda et al., 2000). Differences in P_{sat} measurements are the result of interactions between oxalate extractable P and Al between treatments over time. At T1 there are significant reductions in P_{sat} with increasing amounts of WTR, which was expected due to increases in Al_{ox} with WTR applications (Figure 3B). At T1 the HWTR treatment is 50% of the 0WTR treatment. By T2 this difference is not significant despite the HWTR treatment P_{sat} remaining fairly constant over time. The 0WTR treatment P_{sat} was dramatically reduced between T1 and T2 (Figure 3C). Since Al_{ox} on the 0WTR plots was not altered, the changes in P_{sat} reflect the loss of P due to transport, which can be seen by the reductions in P_{ox}. The P_{ox} of the HWTR treatment was not reduced as dramatically and by T4 the HWTR treatment had 54% more P_{ox} than the 0WTR plots (Figure 3A). This, along with 33% more total P on the HWTR treatment (Figure 4), is strong evidence suggesting that less P transport occurs over time when WTR is co-blended with manure. The increase in Al_{ox}, and the retention of P_{ox} over time when WTR was applied and the reductions of

P_{ox} when WTR was not applied, caused P_{sat} measurements to remain similar across treatments and time after T1.

In Ohio's current P-risk index B1P or M3P are one component used to characterize the risk of P loss. For this reason it is important to understand how WTR affects the results of these soil extractants. Previous research has shown that WTR can reduce M3P and B1P, although these reductions are less than reductions measured by WEP because the acid ammonium fluoride solutions used in M3P and B1P extractions dissolve amorphous aluminum surfaces releasing previously absorbed P (Basta et al., 2000; Dayton and Basta, 2005b; Novak and Watts, 2005b). For this reason, M3P and B1P may underestimate the impact of WTR on P transport (Dayton and Basta, 2005b). B1P and M3P were both reduced by the HWTR treatment but not to as great an extent as WEP, supporting the results of these previous studies (Figure 2).

Another component of Ohio's P-risk index used to characterize the risk of P loss is manure application. The manure application rate and application method contribute to the overall P-risk index score. WTR co-blending as a best management practice is not including as a modifying factor for the potential contribution of manure P transport (Dayton and Basta, 2005b). The only potential impact WTR can have on the risk score is by reduction of B1P or M3P. In the case of recent manure application, soil testing does not adequately reflect P transport risk, but rather the amount and solubility of manure P applied (DeLaune et al., 2004). It is apparent with these results that Ohio's P Risk Index should include a modifying factor to the manure contribution component of the overall risk score so the risk score reflects the reduced P transport when WTR is co-blended with manure. One potential solution is to modify the manure contribution based on relative differences between manure's P transport potential. Elliott et al. (2006) suggested the use of P source coefficients, or manure contribution modifiers, derived from manure WEP to determine the potential risk to water quality. Inclusion of source coefficients allows adjustments of risk index scores to better reflect potential for P transport from recent manure applications. Source coefficients could potentially be derived using the P_{sat} of the manure or co-blended material, as evidenced by the trends in this study.

Conclusions

Co-blending WTR with manure was shown in this study to substantially reduce P transport from surface applied poultry litter. Co-blending WTR with manure to achieve phosphorus saturations of less than 100% may provide the best protection of water quality and may provide a useful method for calibrating WTR application amounts (Elliott et al., 2002). Over the course of a growing season, substantially less P was lost from the plots with an application of manure co-blended with the high amount of WTR (Figure 4). The plot with HWTR had 33% more soil total phosphorus, still on the field, three months after treatment application.

EQIP Eligible Producer

With the help of Jim Will, District Conservationist at the Celina Service Center in Mercer County:

Mr. Gene Homan

Cloverford Rd and US 127

Celina, OH 45822

was identified to cooperate on this project. We are grateful to Mr. Homan for allowing us access to his property.

Field Day:

Hosted at Kottman Hall, OSU August 7, 2008

Showcased, preliminary data and demonstrated methodologies and discussed future research strategies. Invitees included the Ohio EPA Lake Erie Task Force members

References

Agyin-Birikorang, S., G.A. O'Connor, L.W. Jacobs, K.C. Makris, and S.R. Brinton. 2007. Long-term phosphorus immobilization by a drinking water treatment residual. J. Environ. Qual. 36:316-323

Agyin-Birikorang, S. and G.A. O'Connor. 2007. Lability of drinking water treatment residuals (WRT) immobilized phosphorus: Aging and pH effects. J.Environ. Qual. 36:176-1085

Basta, N.T., R.J. Zupanic, and E.A. Dayton. 2000. Evaluating soil test to predict Bermudagrass growth in drinking water treatment residuals with phosphorus fertilizer. J. Environ. Qual. 29:2007-2012

Bray, R.H., and L.T. Kurtz. 1945. Determination of total, organic and available forms of phosphorus in soils. Soil Sci. 59:39-45

Bugbee, G.J., and C.R. Frink. 1985. Alum sludge as a soil amendment: Effects on soil properties and plant growth. Bull. 823. Connecticut Agric. Exp. Stn., New Haven.

Codling, E.E., R.L. Chaney, and C.L. Mulchi. 2000. Use of aluminum- and iron-rich residues to immobilize phosphorus in poultry litter and litter-amended soils. J. Environ. Qual. 29:1924-1931

Daniel, T.C., A.N. Sharpley, and J.L. Lemunyon. 1998. Agricultural phosphorus and eutrophication: a symposium overview. J. Environ. Qual. 27:251-257

Dao, T.H., L.J. Sikora, A. Hamasaki, and R. Chaney. 2001. Manure phosphorus extractability as affected by aluminum- and iron by-products and aerobic composting. J. Environ. Qual. 30:1693-1698

Dayton, E.A., and N.T. Basta. 2005a. A method for determining phosphorus sorption capacity and amorphous aluminum of aluminum-based drinking water treatment residuals. J. Environ. Qual. 34:1112-1118

Dayton E.A., and N. T. Basta. 2005b. Use of drinking water treatment residuals as a potential best management practice to reduce phosphorus risk index scores. J. Environ. Qual. 34:2112

Dayton, E.A., N.T. Basta, C.A. Jakober, and J.A. Hattey. 2003. Using treatment residuals to reduce phosphorus in agricultural runoff. J. Am. Water Works. Assoc. 95(4):1112-1118.

Dayton, E.A., and N.T. Basta. 2001. Characterization of drinking water treatment residuals for use as a soil subtitute. Water Environ. Res. 73:52-57

DeLaune, P.B., P.A. Moore, D.K. Carman, A.N. Sharpley, B.E. Haggard, and T.C. Daniel. 2004. Evaluation of the phosphorus source component in the phosphorus index for pastures. J. Environ. Qual. 33:2192-2200

Elliott, H.A., G.A. O'Connor, P. Lu, and S. Brinton. 2002. Influence of water treatment residuals on phosphorus solubility and leaching. J. Environ. Qual. 31:1362-1369

Elliott H.A., R.C. Brandt, P.J.A. Kleinman, A.N. Sharpley, and D.B. Beegle. 2006. Estimating Source Coefficients for Phosphorus Site Indices. J. Environ. Qual. 35:2195-2201

Elliott, H.A., and B.A. Dempsey. 1991. Agronomic effects of land application of water treatment sludges. J. Am. Water Works Assoc. 83:126-131

Gallimore, L.E., N.T. Basta, D.E. Storm, M.E. Payton, R.H. Huhnke, and M.D. Smolen. 1999. Water treatment residual to reduce nutrients in surface runoff from agricultural land. J. Environ. Qual. 28:1474-1478

Hart, M.R., B.F. Quin, and M.L. Nguyen. 2004 Phosphorus runoff from agricultural land and direct fertilizer effects: A review. J. Environ. Qual. 33:1954-1972

Haustein, G.K., T.C. Daniel, D.M. Miller, P.A. Moore, Jr., and R.W. McNew. 2000. Aluminum-containing residuals influence high-phosphorus soil and runoff water quality. J. Environ. Qual. 29:19-54-1959

Hooda, P.S., A.R. Rendell, A.C. Edwards. P.J.A. Withers, M.N. Aitken, and v.W. Tresdale. 2000. Relating soil phosphorus indices to potential phosphorus release to water. J. Environ. Qual. 29:1166-1171

Humphry, J.B., T.C. Daniel, D.R. Edwards, and A.N. Sharpley. 2002. A portable rainfall simulator for plot-scale runoff studies. Applied Eng. in Agric. 18:199-204

Ippolito, J.A., K.A. Barbarick, and E.F. Redente. 1999. Co-Application Effects of Water Treatment Residuals and Biosolids on Two Range Grasses. J. Environ. Qual. 28:1644-1650

Kleinman, P.J.A., Sharpley, A.N., Wolf A.M. Beegle, D.B., and P.A. Moore. 2002. Measuring water-extractable phosphorus in manure as an indicator of phosphorus in runoff. Soil Sci. Soc. Am. J. 66:2009-2015

Lemunyon, J.L., and R.G. Gilbert. 1993. Concept and need for a phosphorus assessment tool. J. Prod. Agric. 6:341-486

Makris, K.C., G.A. O'Connor, W.G. Harris and T.A. Obreza. 2005. Relative efficacy of a drinking-water treatment residual and alum in reducing phosphorus release from poultry litter. Comun. Soil. Sci. Plant Anal. 36:2657-2675

McKeague, J.A., and J.H. Day. 1993. Ammonium oxalate extraction of amorphous iron and aluminum. p. 241. *In* M.R. Carter (ed.) Soil sampling and methods of analysis. Lewis Publ., Boca Raton, FL.

Mehlich, A. 1984. Mehlich III soil test extractant: A modification of Mehlich II extractant. Commun. Soil Sci. Plant Anal. 15:1409-1416

Miller, W.P. 1987. A solenoid-operated, variable intensity rainfall simulator. Soil Sci. Soc. Am. J. 51:832-834

National Phosphorus Research Project. 2007. National research project for simulated rainfall–surface runoff studies [Online]. North Carolina State Univ., Raleigh, NC. Available at http://www.sera17.ext.vt.edu/Documents/National_P_protocol.pdf

Novak J. M. and D.W. Watts. 2005a. Water treatment residuals aggregate size influences phosphorus sorption kinetics and PMAX values. Soil Sci. 170:425

Novak J.M. and D.W. Watts. 2005b. An alum-based water treatment residual can reduce extractable phosphorus concentrations in three phosphorus-enriched coastal plain soils. J. Environ. Qual. 34:1820-1827

Oladeji, O.O., G.A. O'Connor, and S.R. Brinton. 2007. Surface applied water treatment residuals affect bioavailable phosphorus losses in Florida sands. J. Environ. Management. 88:1593-1600

Paulter, M.C. and J.T. Sims. 2000. Relationships between soil test phosphorus, soluble phosphorus, and phosphorus saturation in Delaware soils. Soil Sci. Soc. Am. J. 64: 765-773

Peters, J.M. and N.T. Basta. 1996. Reduction of excessive bioavailable phosphorus in soils by using municipal and industrial wastes. J. Environ. Qual. 25:1236-1241

SAS Institute. (2002). Version 9.1. SAS Institute, Inc. Cary, NC.

Sharpley, A.N. 1995. Dependence of runoff phosphorus on extractable soil phosphorus. J. Environ. Qual. 24:920-926

Sharpley, A.N., S.C. Chapra, R. Wedepohl, J.T. Sims, T.C. Daniel and K.R. Reddy. 1994. Managing agricultural phosphorus for protection of surface water: Issues and options. J. Environ. Qual. 23: 437-451

Sharpley, A.N. and S.J. Smith. 1989. Prediction of soluble phosphorus transport in agricultural runoff. J. Environ. Qual. 18: 313-316

Sheskin, D.J. 1997. Handbook of parametric and nonparametric statistical procedures. 2nd ed. Chapman and Hall, New York

Tolbert, H.A., T.C. Daniel, J.L. Lemunyon, and R.M. Jones. 2002. Relationship of soil test phosphorus and sampling depth to runoff phosphorus in calcareous and noncalcareous soils. J. Environ. Qual. 31:1380-1387

Vadas, P.A. 2005. Relating soil phosphorus to dissolved phosphorus in runoff: A single extraction coefficient for water quality modeling. J. Environ. Qual. 34:572-580

United States Environmental Protection Agency. Method 6010C. Inductively Coupled Plasma-Atomic Emission Spectrometry. In SW-846; U.S. EPA: Washington, DC, 2007

United States Environmental Protection Agency. 2000. 2000 National Water Quality Inventory. Available at www.epa.gov/305b/2000report. USEPA. Washington, DC.

United States Environmental Protection Agency. Method 3050B. Adid Digestion Of Sediments, Sludges, And Soils. In SW-846; U.S. EPA: Washington, DC, 1996

United States Environmental Protection Agency. Document number ILM04.0b. Contract Laboratory Program Statement of work for inorganic analysis, multi-media, multi-concentration. U.S. EPA: Washington, DC.

United States Geological Survey. 1999. The quality of our nations waters: Nutrients and pesticides. USGS Circ. 1225. USGS Info. Serv., Denver.

U.S. Department of Agriculture-Natural Resource Conservation Service. 2002. Phosphorus index risk assessment procedure worksheet. USDA-NRCS Ohio Field Office Technical Guide http://efotg.nrcs.usda.gov/references/public/OH/Nitrogen_and_Phosphorous_Risk_Assessment_Procedures.pdf.

Wolf, A.M., P.J.A. Kleinman, A.N. Sharpley, and D.B. Beegle. 2005. Development of a water extractable phosphorus test for manure: Inter-laboratory study. Soil Sci. Soc. Am. J. 69:695-700

Table 1. Select properties of materials used and background soil at field location

Property	units	Glynwood Soil	WTR	Poultry Litter
Oxalate Extractable P	g kg^{-1}	0.625	1.59	8.62
Oxalate Extractable Al	g kg^{-1}	1.11	115	0.205
Oxalate Extractable Fe	g kg^{-1}	3.72	0.482	0.404
P_{sat} †	%	18.5	1.20	1860
WEP ‡	mg kg^{-1}	63.6	NA	1556
pH		7.62	7.76	6.97

† Phosphorus Saturation = ((oxalate extractable P)/(oxalate extractable Al + oxalate extractable Fe))*100

‡ 1g: 200 mL Deionized Water Extractable P

Table 2. Mean values of soil test P and runoff P for each treatment across sampling Times (T0 – T4)

	RDP †	RTP ‡	BP1 §	M3P ¶	WEP #	P_{ox} ††	Al_{ox} ‡‡	P_{sat} §§
	mg L^{-1}		mg kg^{-1}					%
				T 0				
Initial	0.148	nd	120	191	15.9	622	1112	18.8
				T 1				
0WTR	32.9	35.4	242	593	51.7	1302	976	44.7
LWTR	33.7	41.0	192	380	26.6	996	1221	29.7
MWTR	10.5	19.9	214	490	29.6	1271	1618	32.8
HWTR	1.00	12.7	163	306	21.1	1565	4505	22.3
				T 2				
0WTR	0.886	2.13	227	342	33.6	950	1180	26.7
LWTR	0.803	1.93	236	465	29.3	1065	1287	30.0
MWTR	0.716	1.70	221	419	24.9	1123	1576	28.3
HWTR	0.386	1.30	167	314	18.4	1170	2853	21.8
				T 3				
0WTR	0.380	2.45	156	358	23.6	893	1041	29.9
LWTR	0.392	3.50	185	441	25.0	1045	1184	34.4
MWTR	0.286	1.91	145	348	21.4	1003	1365	29.8
HWTR	0.262	1.63	128	280	14.5	1196	2789	23.5
				T 4				
0WTR	0.726	2.92	158	339	27.7	846	1006	27.8
LWTR	0.781	2.52	176	398	27.8	976	1098	31.1
MWTR	0.831	2.14	135	295	19.9	758	1254	27.6
HWTR	0.779	2.10	131	212	15.5	1303	3271	23.5

† Runoff Dissolved Phosphorus
‡ Runoff Total Phosphorus
§ Bray-1 Extractable P
¶ Mehlich-3 Extractable P
\# 1g: 10mL deionized water extractable P
†† Oxalate Extractable P
‡‡ Oxalate Extractable Al
§§ Phosphorus Saturation = ((oxalate extractable P)/(oxalate extractable Al + oxalate extractable Fe))*100

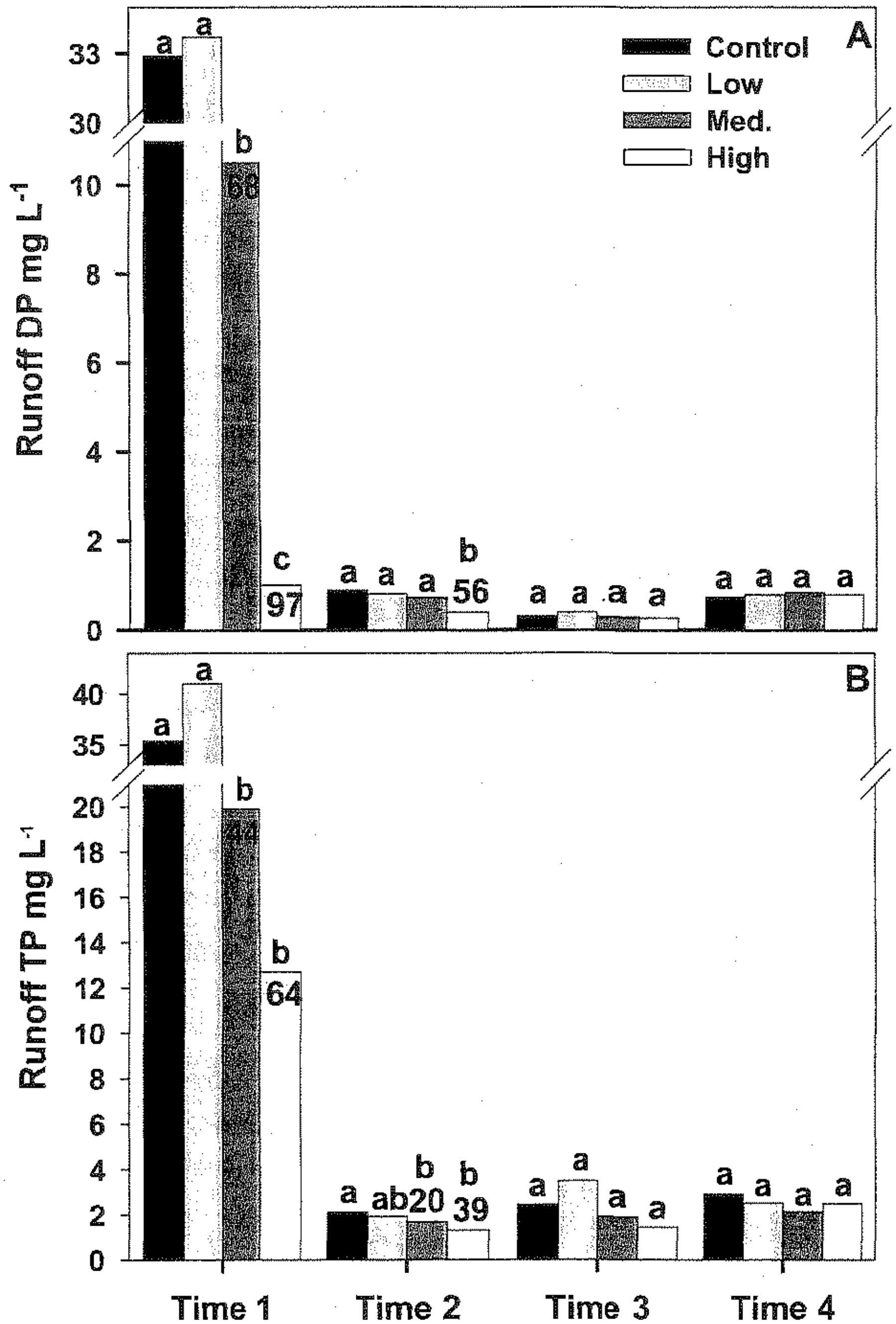


Figure 1. Dissolved (A) and total P (B) in surface runoff. Bars with different letters indicate significant differences within the sampling time. Bars that are significantly different than the control, within the sampling time are labeled with the percent difference from the control.

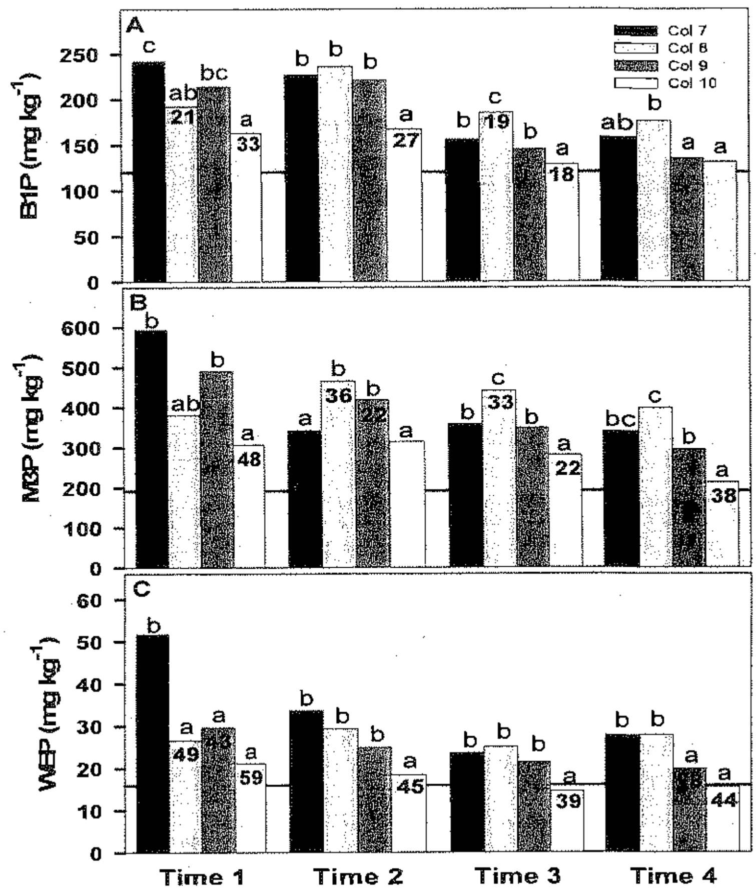


Figure 2. Bray-1 (A), Mehlich 3(B) and deionized water (C) extractable P. Bars with different letters indicate significant differences within the sampling time. Bars that are significantly different from the control, within the sampling time, are labeled with a percent difference from the control. Line indicates a mean initial field value.

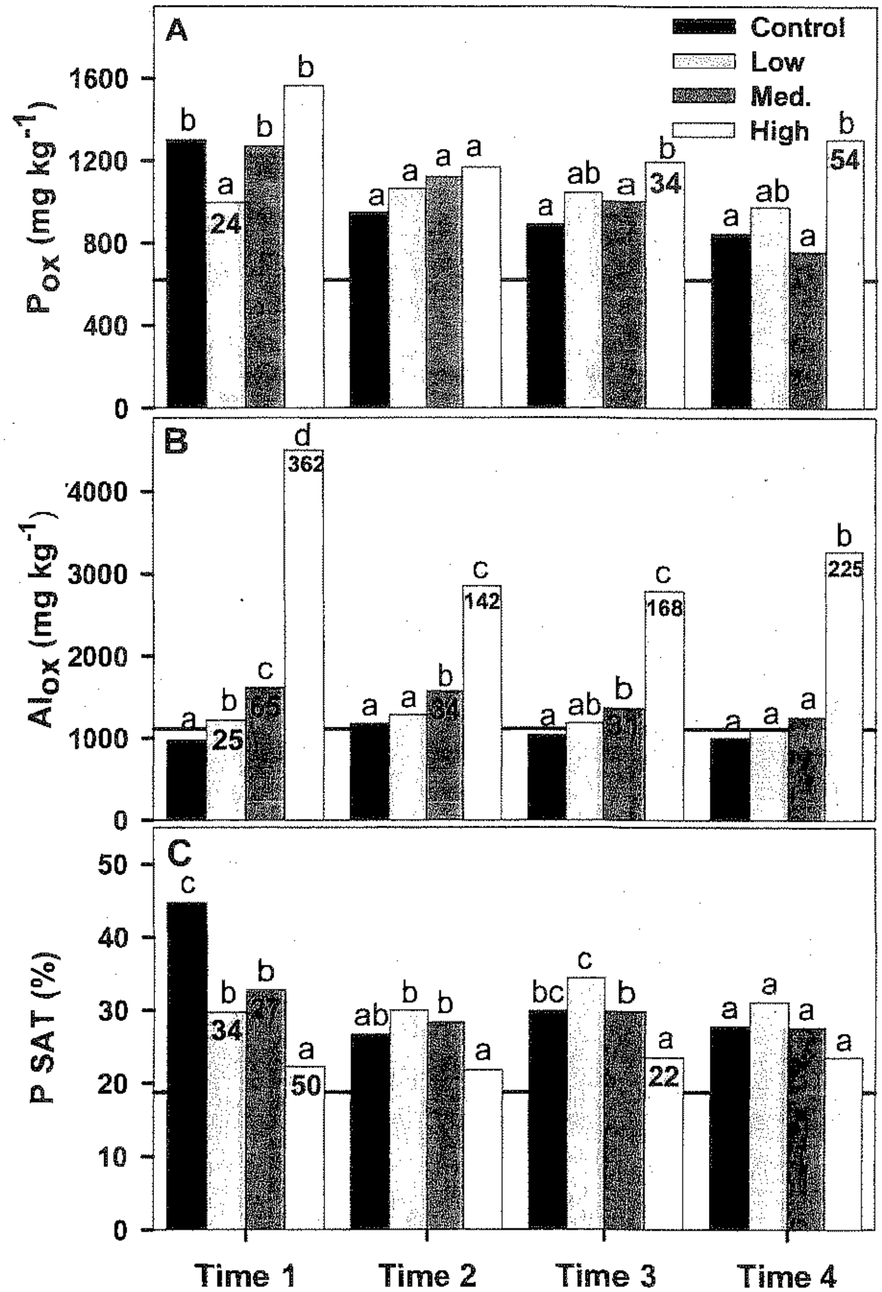


Figure 3. Oxalate extractable P (A), Al (B) and P saturation (C). Bars with different letters indicate significant differences within a sampling time. Bars that are significantly different from the control, within a sampling time, are labeled with the percent difference from the control. Line indicates mean initial field values.

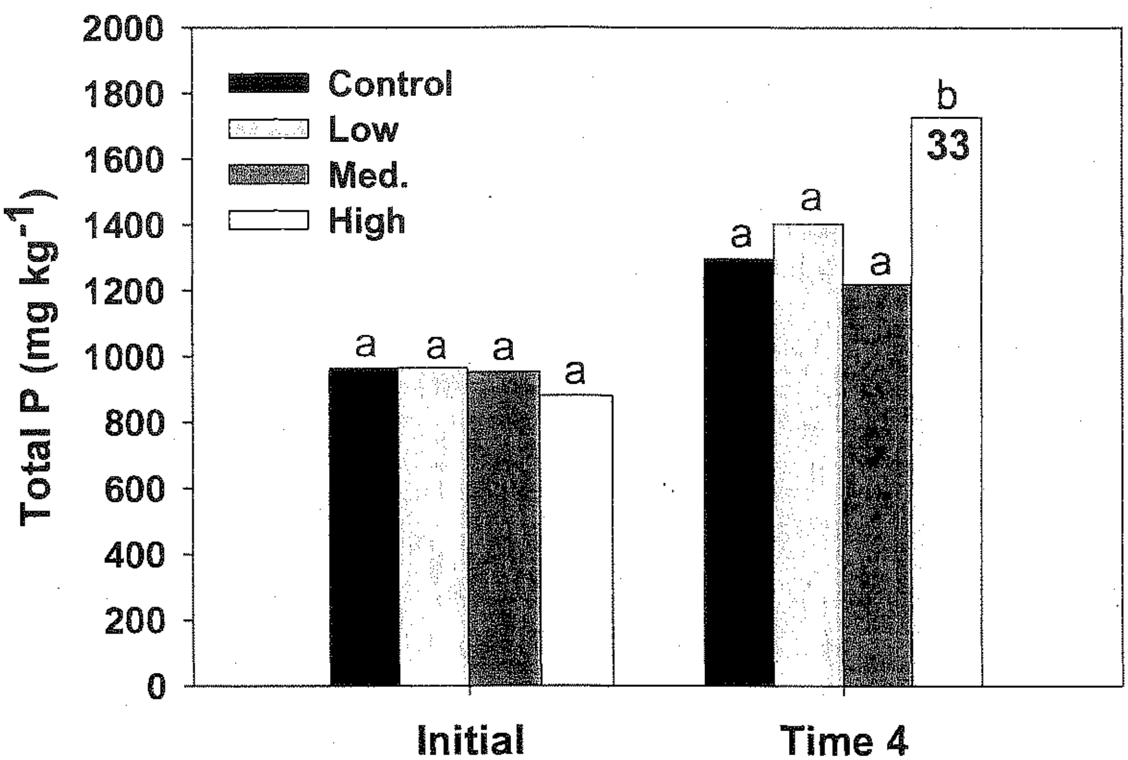


Figure 4. Total soil P from T0, before treatment application, and at T4, three months after treatment application. Bars with different letters indicate significant differences, within a sampling time. Bars that are significantly different than the control, within a sampling time, are labeled with a percent difference from the control.